JACOBS UNIVERSITY

Study Program Handbook

Physics

Bachelor of Science

Contents

1 The Physics Study Program

1.1 Concept

Physics has shaped our view of the universe by studying the basic concepts of space, time and matter. Physics not only lays the foundation for other natural sciences and many engineering disciplines, but is also a fundamental part of modern technology. The Jacobs University physics major is a three year BSc program with emphasis on early involvement in research. The first year starts with a broad introduction to classical and modern physics and their mathematical foundations, complemented by a choice of other subjects. The second year of studies features a thorough education in the theoretical foundations of physics (analytical mechanics, electrodynamics, relativity, and quantum mechanics), more applied fields (solid state and statistical physics, semiconductor devices), computational physics and renewable energy. Lectures are complemented by teaching labs and students are encouraged to join a research group. The third year features a varying selection of specialization courses and guided research leading to the BSc thesis. Students have the opportunity to use the fifth semester for an extended internship or studies abroad.

1.2 Specific Advantages of the Physics Program at Jacobs University

- The three year Jacobs University physics BSc program is unique in its internationality and focus on research. The courses are quite advanced, with a difficulty level comparable to other top international programs, providing an ideal preparation for postgraduate studies of physics and related fields at worldwide leading universities.

- Our graduates are very successful in either getting admitted to top postgraduate programs (MSc/PhD) in physics and related fields, directly entering employment, or starting their own businesses. We use the feedback from our graduates to continuously improve our study program and the graduates themselves benefit from our international alumni network.

- For students with a strong interdisciplinary interest the program easily allows to pursue a minor in one of the other BSc programs at Jacobs University in addition to the regular physics major.

1.3 Program-Specific Qualification Aims

Our main objective is a broad and thorough education in physics with many advanced topics and early exposure to research.

- Students will learn the foundations and advanced concepts of classical and modern physics necessary to explain and understand natural phenomena and to develop new materials, technologies, and advance the description and understanding of nature.

- Students will learn a variety of approaches to describe physical systems using a mathematical formalism. They will be able to develop quantitative mathematical descriptions and computational models to analyze complex systems.

- In lab courses and research projects students will be trained hands-on in advanced experimental methods and techniques in physics to independently design new experiments and evaluate the obtained experimental data.

- Through presentations, lab report preparations, term papers, and the BSc thesis, students will gain familiarity with tools and approaches to access scientific information. They will learn the field-specific terms of physics, and are trained to communicate using the appropriate language of the scientific community.

The analysis of complex systems, logical and quantitative thinking, solid mathematical skills and a broad background in diverse physical phenomena will be a valuable asset for any profession in modern society.

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, competencies 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 will be able to:

- acquire knowledge rapidly, gather, evaluate and interpret relevant information and evaluate new concepts critically to derive scientifically funded judgements;
- apply their knowledge, understanding and methodological competences to their activity or profession to solve problems;
- present themselves and their ideas effectively and to negotiate successfully;
- demonstrate understanding and knowledge of business principles and processes and to manage projects efficiently and independently;
- take responsibility for their and their team's learning and development.

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 to negotiate and mediate between different points of view and to manage conflicts;
- graduates can rely on basic civic knowledge; they are able to analyse global issues of economic, political, scientific, social or technological nature; they are able to evaluate

situations and take decisions based on ethical considerations;
- graduates are able and prepared to take on responsibility for their professional community and society.

1.5 Career Options

A Jacobs University BSc in Physics provides a solid and at the same time flexible foundation for careers in diverse fields, from basic research over engineering and life sciences, to finance and management. The scientific knowledge, the international network, the problem solving and social skills acquired during the studies of physics at Jacobs University guarantee success in our increasingly technology-driven society, as demonstrated by our many very successful graduates. The physics curriculum at Jacobs University is designed to ensure that graduates will be well prepared for postgraduate programs in physics and related fields at world-wide leading universities. The physics program exceeds recommendations of the German Physical Society and all topics required for the GRE physics test are included.

Physicists are the all-rounders among the natural scientists. About two thirds work on advancing our scientific knowledge or develop new technologies, products, and processes. Research positions are found in research centers, scientific institutes, and universities. In industry, physicists work in the fields like IT, software development, electronics, lasers, optics, and semiconductors. An increasing demand for physicists comes also from medical technology. Another large fraction of physicists hold faculty positions at universities and colleges or work in other branches of education. The broad training in analytical skills, technical thinking and the appreciation of complexity and subtlety allows physicists to work - often with additional qualification - as management consultants, patent attorneys, market analysts, or risk managers. Many BSc degree recipients go on to graduate school in physics and other fields, as careers in research and development usually require a postgraduate degree. Here we have an excellent placement record in the top graduate programs. Very helpful for career development is also the opportunity for international network building with Jacobs University students coming from more than a hundred different nations. Good communication skills are essential, since many physicists work as part of a team, have contact to clients with non-physics background, and need to write research papers and proposals. These skills are particularly well developed in the broad and multidisciplinary undergraduate program at Jacobs University.

1.6 More Information and Contact

For more information please contact the study program coordinator:

Dr. Peter Schupp
Professor of Physics
Email: p.schupp@jacobs-university.de
Telephone: +49 421 200-3224

Dr. Jürgen Fritz
Professor of Biophysics
Email: j.fritz@jacobs-university.de
Telephone: +49 421 200-3522

or visit our program website: www.jacobs-university.de/physics-program

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:

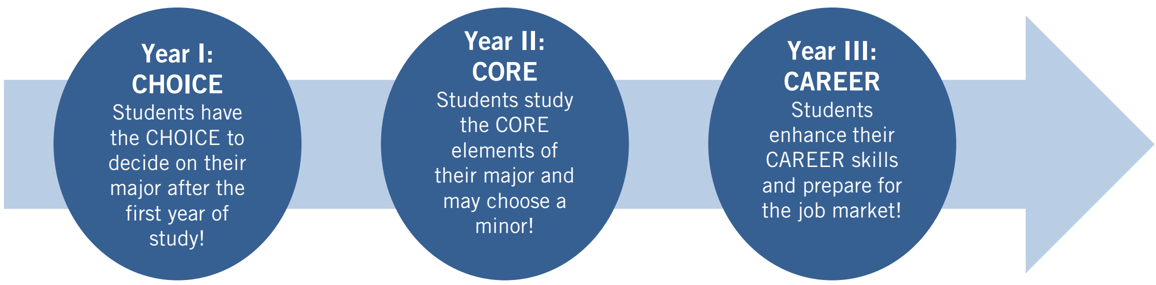


Figure 1: The Jacobs University 3C-Model

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.
     As an alternative to the regular internship, a limited number of students have the opportunity to prepare in a structured manner the formation of their own start-up in the 5th semester, and can attain 20 ECTS for this study-related achievement. Jacobs University cooperates with the City Accelerator Bremen (CAB) to which students can be admitted. There are several requirements which must be fulfilled before the 5th semester in order to be admitted to the CAB, i.e. attendance of specific seminars and workshops and the successful presentation of the business idea within the framework of a competition (pitch). The module is successfully completed, when the student / team of students have submitted the business plan to CAB.

     For further 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.

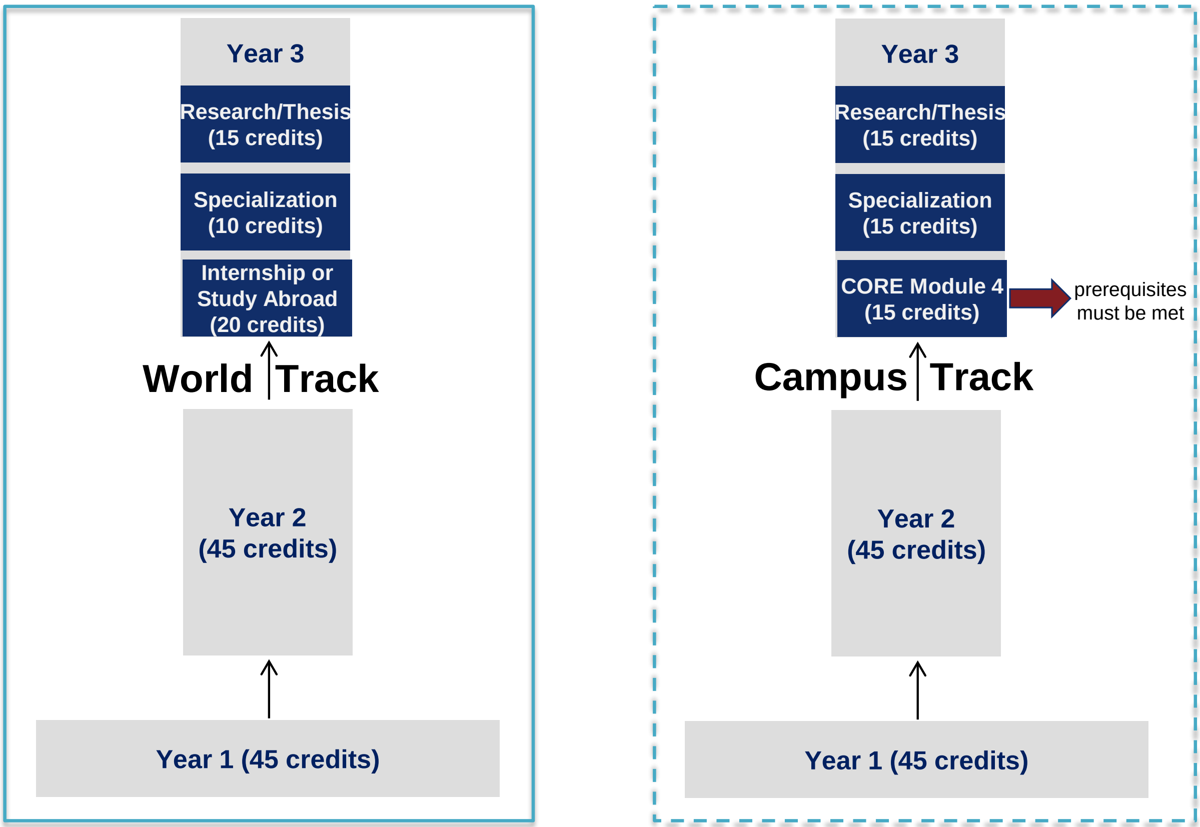


Figure 2: World Track versus Campus Track

Career Advising

Is a mandatory component of the Jacobs University's Advising and Counseling Scheme. Further components are "Academic Advising" and "Psychological Counseling and Intercultural Services". Throughout their studies all students attend a mandatory set of career skills events. The mandatory "Career Skills Advising" 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 include information sessions, compulsory workshops on various career-relevant topics as well as participation in the annual Jacobs Career Fair.

All undergraduate students will be automatically registered for "Career Skills Advising". However, every student has to keep track of his/her individual fulfillment of requirements and has to register on CampusNet for all workshops and sessions during the official registration period at the beginning of each semester. An overview of the sequence in which events should be attended is shown in the table below.

CAREER ADVISING For Undergraduate Students matriculated Fall 2017

SEMESTER	1	2	3	4	5	6
MANDATORY BASICS	CSC-INFO Session: "CSC Services" CA01-990000		CSC-INFO Session: "World Track" CA01-990026			CSC-INFO Session "Professional Networking" CA01-990040
MANDATORY SEMINARS	Both seminars have to be attended in your first or second semester: CSC-APPLICATION TRAINING CA01-990001 CSC-SUCCESS IN STUDIES, CAREER AND LIFE CA01-990031					
MANDATORY ELECTIVE SEMINARS (seminar program subject to availability)			Attend 2 out of several career skills seminars and workshops, i.e. ▪ Research & Contacting Employers ▪ 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: Career Advising

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 Physics Program

Year 1
Take two mandatory modules listed below and select one further CHOICE module from a different study area.

Physics of Natural Systems (CH05-PhysNatSys)
provides an introduction to the physical description of natural phenomena and covers fundamental topics in physics and earth and environmental sciences (EES). Important concepts from mechanics, thermodynamics, fluid dynamics, electromagnetism, atoms and nuclei are introduced and applied to essential processes in Earth, marine, and planetary sciences. Structure and dynamics of natural systems are studied with moderate use of mathematics. Practical sessions will cover important experimental techniques and tools. This module provides a foundation for the higher level EES and Physics modules Earth, Ocean, and Environmental Physics, Statistical Physics and Fields, Applied Physics, Classical and Quantum Dynamics.

Physics and Applied Mathematics (CH06-PhysAppMath)
is an introduction to the mathematical description of natural phenomena. Mathematics is the language and physics is the foundation of all other natural sciences and many engineering disciplines. In this module, we will study fundamental laws of physics and the underlying mathematical concepts and applications. Topics include vector calculus, differential equations, complex analysis; mechanics of systems of particles, oscillations, waves, relativity, electrodynamics, and quantum physics. Lectures are complemented by practical sessions that provide training in computational and experimental skills, including a quantitative analysis of measurements.

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

Statistical Physics and Fields (CO13-StatPhys)
This module provides an introduction to the physics of systems of large numbers of particles and to their continuum field theory limit. All fundamental forces of nature can be formulated in terms of field theories in a way that reconciles classical mechanics with Einstein's relativity theories. In this module we focus on electromagnetic fields, related phenomena and applications. Statistical physics deals with complex systems of large numbers of particles. In this module, we review classical thermodynamics and extended it to a microscopic statistical description of many particle systems. This module complements the module on classical and quantum dynamics. Together they provide a solid foundation for more advanced courses. Accompanying lab courses give deeper insights into the systems discussed in the lectures and provide instructive examples in advanced physics.

Applied Physics (CO14-ApplPhys)
The module discusses advanced applications of physics in modern technology using a descriptive and experimental approach. It builds on the general concepts and methods developed in the Physics of Natural Sciences Module. The first part focuses on energy sources and energy storage technology. It includes the pertinent concepts of thermodynamics and physical chemistry.

The second part introduces computational simulation methods as an important tool, useful for the understanding and investigation of physical systems and for a speed-up of the development of new technologies. Additional lab courses give deeper insights into the systems discussed in the lectures and provide instructive examples of experiments in advanced physics.

Classical and Quantum Dynamics (CO15-ClassDyn)
This module provides a thorough introduction to the theoretical foundations of physics. We will study the physics of particles in the macroscopic world and that of quanta in the atomic realm, while exploring the mathematical structure of nature. The module covers several core topics of physics: Analytical mechanics, special relativity, quantum mechanics and applications. It is complemented by the module on statistical physics and fields, which covers further fundamental topics. Accompanying lab courses give deeper insights into the systems discussed in the lectures and provide instructive examples in advanced physics.

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
   - Physics Project / Thesis Module

   - Program-specific Specialization Module
     Exemplary course offering:
     - Biophysics
     - Particles and Fields
     - Solid-State Electronic Devices
     - Advanced Optics
     - Advanced Quantum Physics
     - Theoretical and Computational Biophysics

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.

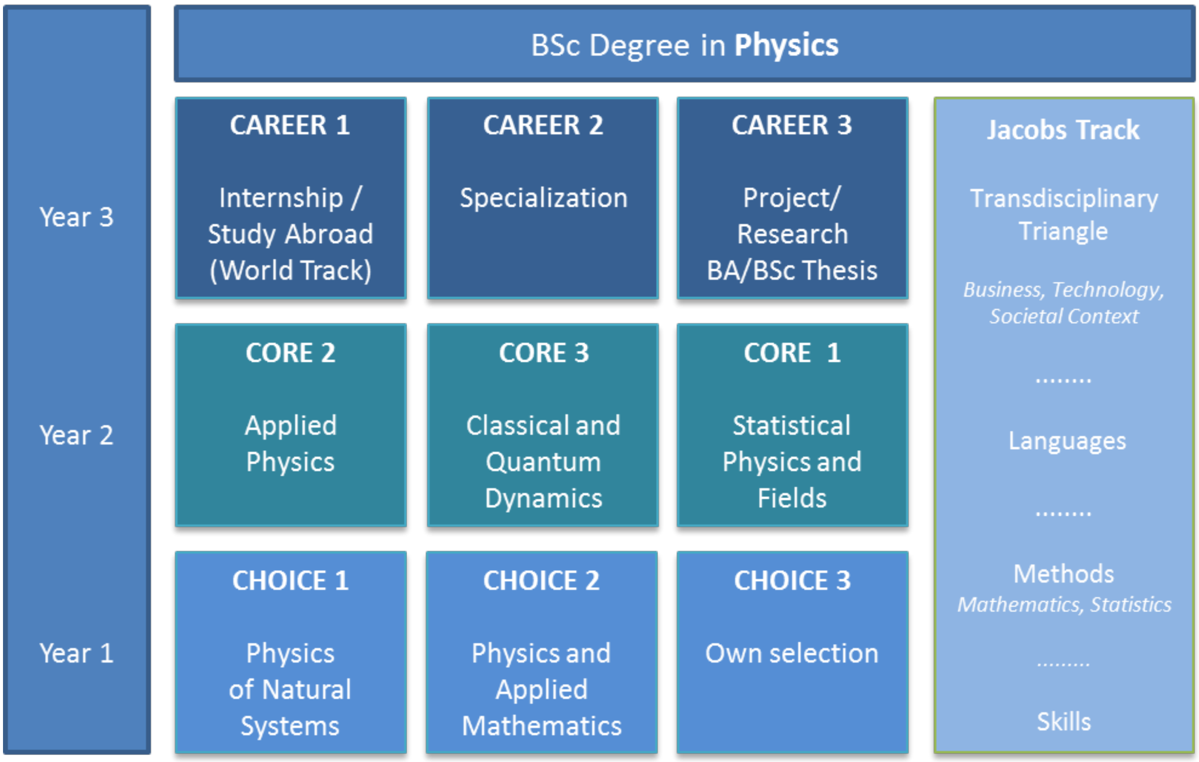
Students are allowed to extend their thesis related work into the intersession or summer break upon approval of the thesis supervisor and Student Records. Students are not allowed to register for different Bachelor Thesis courses in the same semester.

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).

2.6 Structure



YEAR 1	*Take three CHOICE modules, one 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: Physics 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.

Version	Valid as of	Decision	Details
Fall 2017 - V1	01.09.17	AB August 17	Masterversion
Fall 2017 - V2	01.09.17	AB August 17	2.2 revised

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

JACOBS UNIVERSITY

Physics – World Track

Matriculation Fall 2017

Program-Specific Modules		Type	Status[1]	Semester	Credits
Year 1 - CHOICE					**45**
Take the two mandatory CHOICE modules listed below, these are a requirement for the Physics program.					
CH06-PhysAppMath	**Module: Physics and Applied Mathematics**		**m**		**15**
CH06-100101	Applied Mathematics	Lecture	m	1	5
CH06-100111	Applied Mathematics Lab	Lab	m	1	2,5
CH06-200102	Modern Physics	Lecture	m	2	5
CH06-200112	Modern Physics Lab	Lab	m	2	2,5
CH05-PhysNatSys	**Module: Physics of Natural Systems**		**m**		**15**
CH05-200104	Classical Physics	Lecture	m	1	5
CH05-200114	Classical Physics Lab	Lab	m	1	2,5
CH05-210132	Introduction to Earth and Marine Systems	Lecture	m	2	5
CH05-210103	Introduction to Earth System Data	Lab	m	2	2,5
	Module: CHOICE (own selection)		**e**	**1/2**	**15**
Students take one further CHOICE module from those offered for all other study programs. [2]					
Year 2 - CORE					**45**
Take all three modules <u>or</u> replace one with a CORE module from a different study program. [2]					
CO13-StatPhys	**Module: Statistical Physics and Fields**		**me**		**15**
CO13-200213	Electrodynamics	Lecture	m	3	5
CO13-200212	Statistical Physics	Lecture	m	4	5
CO13-200222	Statistical Physics and Fields - Advanced Lab	Lab	m	4	5
CO14-ApplPhys	**Module: Applied Physics**		**me**		**15**
CO14-201231	Renewable Energy	Lecture	m	3	5
CO14-200221	Renewable Energy - Advanced Lab	Lab	m	3	5
CO14-200331	Introduction to Computer Simulation Methods	Lecture	m	4	5
CO15-ClassDyn	**Module: Classical and Quantum Dynamics**		**me**		**15**
CO15-200203	Analytical Mechanics	Lecture	m	3	5
CO15-200202	Quantum Mechanics	Lecture	m	4	5
CO15-200223	Quantum Mechanics - Advanced Lab	Lab	m	4	5
Year 3 - CAREER					**45**
CA02 / CA03	**Module: Internship / Study Abroad**		**m**	**5**	**20**
CA08-PHY	**Module: Project/Thesis PHY**		**m**		**15**
CA08-200303	Project PHY		m	6	5
CA08-200304	Thesis PHY		m	6	10
CAS-WT-PHY	**Module: Specialization Area PHY**		**m**		**10**
	Take four specialization courses (2.5 ECTS each) [2]		me	5/6	10

Jacobs Track Modules (General Education)		Type	Status[1]	Semester	Credits
Year 1					**20**
JT-ME-MethodsMath	**Module: Methods / Mathematics**		**m**		**10**
JT-ME-120103	Calculus I	Lecture	m	1	2,5
JT-ME-120104	Calulus II	Lecture	m	1	2,5
JT-ME-120112	Foundations of Linear Algebra I	Lecture	m	2	2,5
JT-ME-120113	Foundations of Linear Algebra II	Lecture	m	2	2,5
JT-SK-Skills	**Module: Skills**		**m**		**2,5**
JT-SK-990103	Scientific and Experimental Skills	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
CA01-CarAdv	**Career Advising[4]**				
Year 2					**20**
JT-ME-MethodsMath	**Module: Methods / Mathematics**		**m**		**5**
	Take two Methods (mandatory) elective courses (2,5 ECTS each). [2]	Lecture	me	3/4	5
JT-TA-TriArea	**Module: Triangle Area**		**m**		**10**
	Take four courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	3/4	10
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	3/4	5
CA01-CarAdv	**Career Advising[4]**				
Year 3					**5**
JT-SK-Skills	**Module: Skills**		**m**		**2,5**
JT-SK-990104	Advanced Scientific and Experimental Skills		m	6	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	6	2,5
CA01-CarAdv	**Career Advising[4]**				

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).

[4] Mandatory component of the Jacobs University's Counseling and Advising Scheme.

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

Physics – Campus Track

Matriculation Fall 2017

Program-Specific Modules		Type	Status[1]	Semester	Credits
Year 1 - CHOICE					**45**
Take the two mandatory CHOICE modules listed below, these are a requirement for the Physics program.					
CH06-PhysAppMath	**Module: Physics and Applied Mathematics**		**m**		**15**
CH06-100101	Applied Mathematics	Lecture	m	1	5
CH06-100111	Applied Mathematics Lab	Lab	m	1	2,5
CH06-200102	Modern Physics	Lecture	m	2	5
CH06-200112	Modern Physics Lab	Lab	m	2	2,5
CH05-PhysNatSys	**Module: Physics of Natural Systems**		**m**		**15**
CH05-200104	Classical Physics	Lecture	m	1	5
CH05-200114	Classical Physics Lab	Lab	m	1	2,5
CH05-210132	Introduction to Earth and Marine Systems	Lecture	m	2	5
CH05-210103	Introduction to Earth System Data	Lab	m	2	2,5
	Module: CHOICE (own selection)		**e**	**1/2**	**15**
Students take one further CHOICE module from those offered for all other study programs. ²					
Year 2 - CORE					**45**
Take all three modules or replace one with a CORE module from a different study program. ²					
CO13-StatPhys	**Module: Statistical Physics and Fields**		**me**		**15**
CO13-200213	Electrodynamics	Lecture	m	3	5
CO13-200212	Statistical Physics	Lecture	m	4	5
CO13-200222	Statistical Physics and Fields - Advanced Lab	Lab	m	4	5
CO14-ApplPhys	**Module: Applied Physics**		**me**		**15**
CO14-201231	Renewable Energy	Lecture	m	3	5
CO14-200221	Renewable Energy - Advanced Lab	Lab	m	3	5
CO14-200331	Introduction to Computer Simulation Methods	Lecture	m	4	5
CO15-ClassDyn	**Module: Classical and Quantum Dynamics**		**me**		**15**
CO15-200203	Analytical Mechanics	Lecture	m	3	5
CO15-200202	Quantum Mechanics	Lecture	m	4	5
CO15-200223	Quantum Mechanics - Advanced Lab	Lab	m	4	5
Year 3 - CAREER					**45**
COXX	**Module: Additional (4th) CORE module**		**m**	**5/6**	**15**
CA08-PHY	**Module: Project/Thesis PHY**		**m**		**15**
CA08-200303	Project PHY		m	5	5
CA08-200304	Thesis PHY		m	6	10
CAS-CT-PHY	**Module: Specialization Area PHY**		**m**		**15**
	Take **six** specialization courses (2.5 ECTS each) ²		me	5/6	15

Jacobs Track Modules (General Education)		Type	Status[1]	Semester	Credits
Year 1					**20**
JT-ME-MethodsMath	**Module: Methods / Mathematics**		**m**		**10**
JT-ME-120103	Calculus I	Lecture	m	1	2,5
JT-ME-120104	Calulus II	Lecture	m	1	2,5
JT-ME-120112	Foundations of Linear Algebra I	Lecture	m	2	2,5
JT-ME-120113	Foundations of Linear Algebra II	Lecture	m	2	2,5
JT-SK-Skills	**Module: Skills**		**m**		**2,5**
JT-SK-990103	Scientific and Experimental Skills	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
CA01-CarAdv	**Career Advising[4]**				
Year 2					**20**
JT-ME-MethodsMath	**Module: Methods / Mathematics**		**m**		**5**
	Take two Methods (mandatory) elective courses (2,5 ECTS each). ²	Lecture	me	3/4	5
JT-TA-TriArea	**Module: Triangle Area**		**m**		**10**
	Take four courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS ³		me	3/4	10
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	3/4	5
CA01-CarAdv	**Career Advising[4]**				
Year 3					**5**
JT-SK-Skills	**Module: Skills**		**m**		**2,5**
JT-SK-990104	Advanced Scientific and Experimental Skills		m	6	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	5	2,5
CA01-CarAdv	**Career Advising[4]**				

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).

⁴ Mandatory component of the Jacobs University's Counseling and Advising Scheme.

Appendix 2 - Course Data

Course Name	**Course No**	**ECTS**
Classical Physics	CH05-200104	5
Module Affiliation	**Workload (hrs / sem)**	**Level**
CH05-PhysNatSys Physics of Natural Systems	Contact Time: 35,00 Private Study: 90,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

Physics is the most fundamental of all natural sciences. A thorough background and understanding of physics is important for any description of natural systems. This course introduces to the basic principles of mechanics, thermodynamics, and optics. Emphasis is laid on general principles and fundamental concepts for the understanding of natural phenomena, not on an extensive mathematical description. Nevertheless, some basic calculus will be necessary to develop a scientific sound description of physical phenomena. Experiments and demonstrations are included in the lecture, and a tutorial is offered to discuss homework and topics of interest in more details.

The course consists of three main sections: The section on mechanics introduces the description of motion and the concepts of force and energy, including collisions, rotations, gravitation, and oscillations. The section on thermodynamics adds the concepts of heat and temperature to the description of natural systems including heat capacity, ideal gases, internal energy and the first law of thermodynamics. The section on optics introduces the concepts of light rays and waves to discuss optical instruments and the phenomena of interference and diffraction.

Methods of Assessment

Name	Weighting
Final Exam	50%
Home Work	20%
Midterm Exam	30%

Course Name	**Course No**	**ECTS**
Classical Physics Lab	CH05-200114	2,5
Module Affiliation	**Workload (hrs / sem)**	**Level**
CH05-PhysNatSys Physics of Natural Systems	Contact Time: 25,50 Private Study: 37,00	Bachelor 1st Year CHOICE

Course Description / Content / Aims

Physics is an experimental science and the ultimate test for any theory or description of nature is the experiment. This lab course complements the Classical Physics lecture with experiments in the fields of mechanics, thermodynamics and optics. It deepens the understanding and extends the topics covered in the lecture, which is a corequisite for this course. Prior to the course, students need to attend the relevant safety instructions and will get an introduction into error analysis and calculation. The lab offers six different experiments and runs over six afternoons. The aim of the lab sessions is hands-on experience on how to investigate physical phenomena and topics presented in the lecture; to plan, carry out, and analyse experiments in physics; to describe, summarize and present experimental results adequately. Examples of experiments include the mathematical pendulum, ideal gas law and optical instruments.

Methods of Assessment

Name	Weighting
Final Exam	34%
Lab Reports	66%

Appendix 2 - Course Data

Course Name Introduction to Earth System Data	***Course No*** CH05-210103	***ECTS*** 2,5
Module Affiliation CH05-PhysNatSys Physics of Natural Systems	***Workload (hrs / sem)*** Contact Time: 17,50 Private Study: 45,00	***Level*** Bachelor 1st Year CHOICE

Course Description / Content / Aims
The course provides an early exposure to Earth data and their handling. The wide range of remotely or in-situ collected datasets will be introduced and examples provided, as well as their relevance for Earth science disciplines. Three main components of the course are included: a) an overview of the range of data types, standards, and formats commonly use in Earth science and exemplary data sources and data search, discovery, retrieval and inspecting options, b) exemplary Earth science data collection activities, and c) data handling and analysis basics, covering either archive or field-collected data. Geospatial and temporal data of interest and relevance for Earth and Marine sciences will be described, collected, inspected and analyzed with available open source tools.

Course Name Introduction to Earth and Marine Systems	***Course No*** CH05-210132	***ECTS*** 5
Module Affiliation CH05-PhysNatSys Physics of Natural Systems	***Workload (hrs / sem)*** Contact Time: 35,00 Private Study: 90,00	***Level*** Bachelor 1st Year CHOICE

Course Description / Content / Aims
Planet Earth is a natural system comprising a number of compartments such as the interior, the continents, the oceans, and the atmosphere. In this course you are introduced to the complex interplay of earth and marine processes on a wide range of spatial and temporal scales. Earth's history and planetary evolution define our place in space and time. Plate tectonics and surface structures are closely linked to the composition and the dynamics of the planetary interior. We discuss the physical forces and hydrodynamical principles on our rotating planet that govern ocean currents and also atmospheric dynamics on large spatial scales.

Appendix 2 - Course Data

Course Name Applied Mathematics	***Course No*** CH06-100101	***ECTS*** 5
Module Affiliation CH06-PhysAppMath Physics and Applied Mathematics	***Workload (hrs / sem)*** Contact Time: 35,00 Private Study: 90,00	***Level*** Bachelor 1st Year CHOICE

Course Description / Content / Aims

Mathematics is the language of physics and an indispensable tool with applications in all sciences, engineering, economy and many other aspects of human society. This course provides an introduction to applied mathematics with focus on applied analysis, vector calculus and differential equations. Applications in physics and other natural sciences are discussed in detail. Topics: review of single variable differentiation and integration; ordinary differential equations, equations of motion, damped and driven oscillations, RLC circuits; Fourier transform; systems of particles, systems in equilibrium (statics), 2-body central force problem; introduction to vectors, matrices, eigenvalues and eigenvectors; spacetime isometries, time-dependent rotations, angular momentum, tensor of inertia, and principal axes; vector calculus, gradient, curl, divergence; partial differential equations, wave equation, Schrödinger equation, Maxwell’s equations.

Methods of Assessment

Name	Weighting
Final Exam	40%
Home Work	20%
Midterm Exam	20%
Quizz(es)	20%

Course Name Applied Mathematics Lab	***Course No*** CH06-100111	***ECTS*** 2,5
Module Affiliation CH06-PhysAppMath Physics and Applied Mathematics	***Workload (hrs / sem)*** Contact Time: 25,50 Private Study: 37,00	***Level*** Bachelor 1st Year CHOICE

Course Description / Content / Aims

This lab complements the lectures on Applied Mathematics and provides a practical introduction to programming, numerical and/or symbolic computation with many examples.

Methods of Assessment

Name	Weighting
Attendance and Active Participation	30%
Computer Assignments	40%
Theory Exam	30%

Appendix 2 - Course Data

Course Name Modern Physics	***Course No*** CH06-200102	***ECTS*** 5
Module Affiliation CH06-PhysAppMath Physics and Applied Mathematics	***Workload (hrs / sem)*** Contact Time: 35,00 Private Study: 90,00	***Level*** Bachelor 1st Year CHOICE
Course Description / Content / Aims Modern technology and the understanding of natural systems is heavily based on electromagnetic phenomena and the physics of the 20th century. This course introduces the basic principles and phenomena of electromagnetism and modern physics. Emphasis is laid on the understanding of general principles and phenomena supported by an adequate mathematical description. Experiments and demonstrations are included in the lecture, and a tutorial is offered to discuss homeworks and topics of interest in more detail. The course consists of two main sections: The electromagnetism part is an introduction to basic electric and magnetic phenomena using the concepts of force, fields, and potentials. This is followed by a discussion of dielectrics and magnetism in matter, electric currents, induction, and Maxwell equations. In the modern physics part new concepts from relativity and quantum physics are introduced to describe properties and interactions of particles. This includes a discussion of the particle nature of light and the wave-like nature of particles, Schrödinger's equation, energy levels of atoms, spin, molecules and solids, nuclear physics, elementary particles and the standard model of particle physics.		

Course Name Modern Physics Lab	***Course No*** CH06-200112	***ECTS*** 2,5
Module Affiliation CH06-PhysAppMath Physics and Applied Mathematics	***Workload (hrs / sem)*** Contact Time: 25,50 Private Study: 37,00	***Level*** Bachelor 1st Year CHOICE
Course Description / Content / Aims Physics is an experimental science and the ultimate test of any theory or description of nature is the experiment. This lab course complements the Modern Physics lecture course with experiments in the fields of electromagnetism and modern physics. It deepens the understanding and extends the topics covered in the lecture, which is a corequisite for this course. This course builds on the Classical Physics lab course, but it can also be taken independently. Prior to the course, students need to attend the relevant safety instructions and will get an introduction to error analysis. The lab offers six different experiments and runs over six afternoons. The aim of the lab sessions is hands-on experience on how to investigate physical phenomena and topics presented in the lecture; to plan, carry out, and analyse experiments in physics; to describe, summarize and present experimental results adequately. Examples of experiments include Coulomb force, Franck-Hertz experiment, and radioactivity.		

Appendix 2 - Course Data

Course Name Statistical Physics	***Course No*** CO13-200212	***ECTS*** 5
Module Affiliation CO13-StatPhys Statistical Physics and Fields	***Workload (hrs / sem)*** Contact Time: 35,00 Private Study: 90,00	***Level*** Bachelor 2nd Year CORE
Course Description / Content / Aims Statistical physics describes macroscopic properties of matter by a statistical treatment of their microscopic constituents and can be applied in different fields ranging from biophysics to condensed matter and high energy physics. This course deals with an intensive introduction to statistical physics and its applications in condensed matter theory. The course starts with an introduction to the mathematical concepts followed by a very brief review of the thermodynamic concepts and quantities. Topics in statistical physics include the statistical basis of thermodynamics, micro-canonical, canonical and grand-canonical ensembles, macroscopic variables, physical applications up to an introduction to quantum statistical physics like Fermi and Bose quantum gases, and related physical phenomena. Based on the multi-particle wave functions of Fermions, applications in condensed matter physics are discussed, including Bloch wave functions and the density of states.		

Course Name Electrodynamics	***Course No*** CO13-200213	***ECTS*** 5
Module Affiliation CO13-StatPhys Statistical Physics and Fields	***Workload (hrs / sem)*** Contact Time: 35,00 Private Study: 90,00	***Level*** Bachelor 2nd Year CORE
Course Description / Content / Aims Electrodynamics is the prototype theory for all fundamental forces of nature. It plays a profound role in modern communication, computing and control systems, as well as energy production, transport, storage and use. This course provides an intensive calculus-based introduction to electrodynamics. Topics include: Electromagnetic fields, Maxwell's equations, electrostatics, magnetostatics, fields in matter, covariant formulation of electrodynamics and special relativity, electromagnetic radiation, and optics. The course is part of the core physics education and builds in an essential way on the foundation of Physics and Applied Mathematics module. The course is however also accessible and of interest to students without this prerequisite, but with a sufficiently strong background in mathematics.		

Appendix 2 - Course Data

JACOBS UNIVERSITY

Course Name	***Course No***	***ECTS***
Statistical Physics and Fields - Advanced Lab	CO13-200222	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO13-StatPhys Statistical Physics and Fields	Contact Time: 51,00 Private Study: 74,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

This second year physics lab course offers advanced experiments related to electrodynamics, statistical physics and aspects of condensed matter physics. It deepens the understanding, but also extends or introduces the topics taught in the lectures of the Statistical Physics and Fields module. It requires previous exposure to a physics-related first year lab course and its related experimental methods and analysis. Participants carry out six experiments with each experiment occupying two afternoons. Students expand their experimental skills by gaining practical experience with advanced experimental and evaluation methods. Examples of experiments include the Hall effect, Nd:YAG laser, diffraction and dispersion.

Course Name	***Course No***	***ECTS***
Renewable Energy - Advanced Lab	CO14-200221	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO14-ApplPhys Applied Physics	Contact Time: 51,00 Private Study: 74,00	Bachelor 2nd Year CORE

Course Description / Content / Aims

This second year physics lab course offers advanced experiments related to thermodynamics and renewable energy topics. It deepens the understanding, but also extends or introduces the topics covered in the Renewable Energy lecture. Previous exposure to a first year lab course and the related experimental analysis methods is recommended when taking this lab. Participants carry out six experiments with each experiment occupying two afternoons. The lab will introduce students to advanced experimental and evaluation methods in physics. Examples of experiments include wind tunnel, Stirling engine, and fuel cell.

Appendix 2 - Course Data

Course Name	**Course No**	**ECTS**
Introduction to Computer Simulation Methods	CO14-200331	5
Module Affiliation CO14-ApplPhys Applied Physics	***Workload (hrs / sem)*** Contact Time: 35,00 Private Study: 90,00	***Level*** Bachelor 2nd Year CORE

Course Description / Content / Aims
This introductory course on Computer Simulation Methods discusses a number of practical numerical solutions for typical problems in the natural sciences. While, for example, the very nature of physics is the expression of relationships between physical quantities in mathematical terms, an analytic solution of the resulting equations is often not available. Instead, numerical solutions based on computer programs are required to obtain useful results for real-life problems. In this course several numerical techniques are introduced, such as solving differential equations of motion, partial differential equations, random number generation and standard as well as Monte Carlo integration, which are important tools in any numerical approach. These methods will be applied to a selection of problems including the classical dynamics of particles, traffic simulations, simple electrostatics, random processes, cellular automata, etc. Since the course includes numerous examples and exercises for programming codes, some programming skills in C, Fortran or Python are strongly recommended as prerequisites.

Course Name	**Course No**	**ECTS**
Renewable Energy	CO14-201231	5
Module Affiliation CO14-ApplPhys Applied Physics	***Workload (hrs / sem)*** Contact Time: 35,00 Private Study: 90,00	***Level*** Bachelor 2nd Year CORE

Course Description / Content / Aims
Renewable energy resources promise to provide clean, decentralized solutions to the world energy crisis, as energy resources which directly depend on the power of the sun's radiation. The course gives an overview of the potential and limitations of energy resources. It includes a self-contained introduction to classical thermodynamics.
We start with an overview of energy scenarios based on current energy needs and available energy resources. After an introduction to the basic physics of solar energy and the basics of thermodynamics we cover physics and engineering aspects of solar cells, solar thermal collectors, wind power, geothermal power, thermophotovoltaics, the potential of biomass energy resources, hydro, tidal and wave energy. A basic introduction to energy transport and energy storage is given. We also give an introduction to the basic physics of other energy resources, in particular nuclear energy.

Appendix 2 - Course Data

Course Name Quantum Mechanics	**Course No** CO15-200202	**ECTS** 5
Module Affiliation CO15-ClassDyn Classical and Quantum Dynamics	**Workload (hrs / sem)** Contact Time: 35,00 Private Study: 90,00	**Level** Bachelor 2nd Year CORE
Course Description / Content / Aims At a fundamental microscopic level our world is governed by quantum phenomena that frequently defy attempts of a common sense understanding based on our everyday experience of the macroscopic world. Yet modern technology would not be possible without quantum physics. This course provides an intensive introduction to quantum mechanics. We shall emphasize conceptual as well as quantitative aspects of the theory. Topics include: Foundation and postulates of quantum mechanics; Schrödinger Equation; one-dimensional problems (potential barriers and tunneling); operators, matrices, states (Dirac notation, representations); uncertainty relations; harmonic oscillator, coherent states; angular momentum and spin; central potential (hydrogen atom, multi-electron atoms); perturbation theory; mixed states, entanglement, measurement. Some illustrative examples from quantum information theory (quantum computing) will be discussed. The course is part of the core physics education and is also of interest for students of other natural sciences and mathematics.		

Course Name Analytical Mechanics	**Course No** CO15-200203	**ECTS** 5
Module Affiliation CO15-ClassDyn Classical and Quantum Dynamics	**Workload (hrs / sem)** Contact Time: 35,00 Private Study: 90,00	**Level** Bachelor 2nd Year CORE
Course Description / Content / Aims Mechanics provides the foundation for all other fields of physics. The analytical techniques developed in mechanics have applications in many other sciences, engineering, mathematics and even economics. This course provides an intensive calculus-based introduction to analytical mechanics and special relativity. Topics include: Newton's laws, kinematics and dynamics of systems of particles, planetary motion, rigid body mechanics, Lagrangian mechanics, variational techniques, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, small oscillations, and relativistic mechanics. The course is part of the core physics education and builds on the foundation of the Physics and Applied Mathematics module. The course is however also accessible and of interest to students without this prerequisite, but with a sufficiently strong background in mathematics.		

Appendix 2 - Course Data

Course Name Quantum Mechanics – Advanced Lab	***Course No*** CO15-200223	***ECTS*** 5
Module Affiliation CO15-ClassDyn Classical and Quantum Dynamics	***Workload (hrs / sem)*** Contact Time: 51,00 Private Study: 74,00	***Level*** Bachelor 2nd Year CORE

Course Description / Content / Aims

This second year physics lab course offers advanced experiments related to analytical mechanics, quantum mechanics, and atomic physics. It deepens the understanding, but also extends or introduces the topics covered in the lectures of the Classical and Quantum Dynamics Module. It requires previous exposure to a physics-related first year lab course and its related experimental methods and analysis. Participants carry out six experiments with each experiment occupying two afternoons. Students expand their experimental skills by gaining practical experience with advanced experimental and evaluation methods. Examples of experiments include gyroscope and Coriolis force, Stern Gerlach experiment, electron spin and NMR.