

# MODULE HANDBOOK

## **Bachelor of Engineering**

Bachelor Engineering (FS-OI-BAENG)

**180 ECTS**

**Distance Learning**

Classification: Undergraduate

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2022-08-15



# 1. Semester

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## Engineering: Branches, Methods, Applications, Trends

Module Code: DLBENGEBMAT

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	None	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
1. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Dorian Mora (Engineering: Branches, Methods, Applications, Trends)

### Contributing Courses to Module

- Engineering: Branches, Methods, Applications, Trends (DLBENGEBMAT01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam or Written Assessment: Written  
Assignment

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Historical Evolution
- Branches
- Methods
- Applications
- Trends

**Learning Outcomes****Engineering: Branches, Methods, Applications, Trends**

On successful completion, students will be able to

- describe the historical evolution of engineering.
- understand the meaning of engineering and how its different branches evolved.
- name and describe the different branches of engineering and their common foundations.
- name and understand current and future trends in the field of engineering.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field

# Engineering: Branches, Methods, Applications, Trends

Course Code: DLBENGEBMAT01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

## Course Description

In the present days, the foundation for all engineering activities is comprehensive knowledge in the fields of natural science, mathematics, and computer science, whereas the influence of computer science is steadily growing due to the advances of the so-called digital transformation and its impact of the whole modern civilization. On this common foundation many different branches or disciplines evolved over the time, e.g., mechanical engineering, electrical engineering, biological engineering, and software engineering. This course, thus, provides an overview of the whole field of engineering, its historical evolution, and the formation of the different branches. When describing the evolution and the different branches, many important and prominent applications as well as methods will be presented, too. Finally, some selected and significant current and future trends are described.

## Course Outcomes

On successful completion, students will be able to

- describe the historical evolution of engineering.
- understand the meaning of engineering and how its different branches evolved.
- name and describe the different branches of engineering and their common foundations.
- name and understand current and future trends in the field of engineering.

## Contents

1. History and Evolution of Engineering
  - 1.1 Prehistoric Times and Ancient Era
  - 1.2 Middle Ages
  - 1.3 European Renaissance and Modern Era
  - 1.4 Common Inducements in all Eras
2. Common Foundations of Modern Engineering
  - 2.1 Natural Science and Mathematics
  - 2.2 Methods and Technologies
  - 2.3 Computer Science

3. Main Classical Branches of Engineering
  - 3.1 Mechanical Engineering
  - 3.2 Civil Engineering
  - 3.3 Chemical Engineering
  - 3.4 Electrical Engineering
4. Important and Selected Interdisciplinary Branches of Engineering
  - 4.1 Computer Engineering
  - 4.2 Mechatronics engineering
  - 4.3 Biomedical engineering
  - 4.4 Systems Engineering
5. Other Relationships and Social Context
  - 5.1 Relationships with other Disciplines
  - 5.2 Social Context
6. Current and Future Trends
  - 6.1 Sustainability and Renewable Energy
  - 6.2 Artificial Intelligence Integration
  - 6.3 Advanced Robotics and Automation
  - 6.4 Biotechnology and Biological Engineering

**Literature****Compulsory Reading****Further Reading**

- Basalla, G. (2010). The Evolution of Technology. Cambridge University Press.
- Blockley, D. (2012). Engineering: A Very Short Introduction. Oxford University Press Inc.
- Brain, M. (2015). The Engineering Book: From the Catapult to the Curiosity Rover, 250 Milestones in the History of Engineering. Sterling Publishing Co., Inc.
- Dorf, R. C. (2005). The Engineering Handbook (2 ed.). CRC Press LLC.
- Gribbin, J. (2003). Science: A History. Penguin Books Ltd.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam or Written Assessment: Written Assignment

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
100 h	0 h	25 h	25 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBENGEBMAT01



## Introduction to Academic Work

Module Code: DLBCSIAW

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
1. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Maya Stagge (Introduction to Academic Work)

### Contributing Courses to Module

- Introduction to Academic Work (DLBCSIAW01)

### Module Exam Type

#### Module Exam

Study Format: myStudies  
Basic Workbook (passed / not passed)

Study Format: Distance Learning  
Basic Workbook (passed / not passed)

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Scientific Theoretical Foundations and Research Paradigms
- Application of Good Scientific Practice
- Methodology
- Librarianship: Structure, Use, and Literature Management
- Forms of Scientific Work at IU

**Learning Outcomes****Introduction to Academic Work**

On successful completion, students will be able to

- understand and apply formal criteria of a scientific work.
- distinguish basic research methods and identify criteria of good scientific practice.
- describe central scientific theoretical basics and research paradigms and their effects on scientific research results.
- use literature databases, literature administration programs, and other library structures properly; avoid plagiarism; and apply citation styles correctly.
- apply the evidence criteria to scientific texts.
- define a research topic and derive a structure for scientific texts.
- compile a list of literature, illustrations, tables, and abbreviations for scientific texts.
- understand and distinguish between the different forms of scientific work at IU.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Methods

**Links to other Study Programs of the University**

All Bachelor Programmes in the Business & Management field

## Introduction to Academic Work

Course Code: DLBCSIAW01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

The application of good scientific practice is one of the basic academic qualifications that should be acquired while studying. This course deals with the distinction between everyday knowledge and science. This requires a deeper understanding of the theory of science, as well as the knowledge of basic research methods and instruments for writing scientific texts. The students therefore gain initial insight into academic research and are introduced to the basic knowledge that will help them in the future to produce scientific papers. In addition, the students receive an overview of the different IU examination forms and insight into their requirements and implementation.

### Course Outcomes

On successful completion, students will be able to

- understand and apply formal criteria of a scientific work.
- distinguish basic research methods and identify criteria of good scientific practice.
- describe central scientific theoretical basics and research paradigms and their effects on scientific research results.
- use literature databases, literature administration programs, and other library structures properly; avoid plagiarism; and apply citation styles correctly.
- apply the evidence criteria to scientific texts.
- define a research topic and derive a structure for scientific texts.
- compile a list of literature, illustrations, tables, and abbreviations for scientific texts.
- understand and distinguish between the different forms of scientific work at IU.

### Contents

1. Theory of Science
  - 1.1 Introduction to Science and Research
  - 1.2 Research Paradigms
  - 1.3 Fundamental Research Decisions
  - 1.4 Effects of Scientific Paradigms on Research Design

2. Application of Good Scientific Practice
  - 2.1 Research Ethics
  - 2.2 Evidence Teaching
  - 2.3 Data Protection and Affidavit
  - 2.4 Orthography and Shape
  - 2.5 Identification and Delimitation of Topics
  - 2.6 Research Questions and Structure
3. Research Methods
  - 3.1 Empirical Research
  - 3.2 Literature and Reviews
  - 3.3 Quantitative Data Collection
  - 3.4 Qualitative Data Collection
  - 3.5 Mix of Methods
  - 3.6 Critique of Methods and Self-Reflection
4. Librarianship: Structure, Use, and Literature Management
  - 4.1 Plagiarism Prevention
  - 4.2 Database Search
  - 4.3 Literature Administration
  - 4.4 Citation and Author Guidelines
  - 4.5 Bibliography
5. Scientific Work at the IU – Research Essay
6. Scientific Work at the IU - Project Report
7. Scientific Work at the IU - Case Study
8. Scientific Work at the IU - Bachelor Thesis
9. Scientific Work at the IU – Oral Assignment
10. Scientific Work at the IU – Oral Project Report
11. Scientific Work at the IU - Colloquium
12. Scientific Work at the IU - Portfolio
13. Scientific Work at the IU - Exam

**Literature****Compulsory Reading****Further Reading**

- Bell, J., & Waters, S. (2018). *Doing your research project: A guide for first-time researchers* (7th ed.). Open University Press McGraw-Hill Education.
- Deb, D., Dey, R., & Balas, V. E. (2019). *Engineering research methodology: A practical insight for researchers*. Springer.
- Saunders, M., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students* (8th ed.). Pearson.
- Veal, A. J. (2018). *Research Methods for Leisure and Tourism* (5th ed.). Pearson.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Basic Workbook (passed / not passed)

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Basic Workbook (passed / not passed)

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBCSIAW01



## Mathematics: Linear Algebra

Module Code: DLBDSMFLA

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
1. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Robert Graf (Mathematics: Linear Algebra)

### Contributing Courses to Module

- Mathematics: Linear Algebra (DLBDSMFLA01)

### Module Exam Type

#### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Matrix algebra
- Vector spaces
- Linear and affine transformations
- Analytical geometry
- Matrix decomposition

**Learning Outcomes****Mathematics: Linear Algebra**

On successful completion, students will be able to

- explain fundamental notions in the domain of linear equation systems.
- exemplify properties of vectors and vector spaces.
- summarize characteristics of linear and affine mappings.
- identify important relations in analytical geometry.
- utilize different methods for matrix decomposition..

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Methods

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology fields

# Mathematics: Linear Algebra

Course Code: DLBDSMFLA01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Linear algebra is a fundamental subject in mathematics. Its historical origin lies in the development of solution techniques for systems of linear equations arising from geometric problems. Numerous scientific and engineering applications can be solved using its methods. This course introduces the foundations of linear algebra and its basic notions like vectors and matrices. It then builds upon this foundation by introducing the derivation of solution techniques for problems in analytical geometry.

## Course Outcomes

On successful completion, students will be able to

- explain fundamental notions in the domain of linear equation systems.
- exemplify properties of vectors and vector spaces.
- summarize characteristics of linear and affine mappings.
- identify important relations in analytical geometry.
- utilize different methods for matrix decomposition..

## Contents

1. Foundations
  - 1.1 Systems of Linear Equations
  - 1.2 Matrices: Basic Terms
  - 1.3 Matrix algebra
  - 1.4 Matrices as compact representations of linear equations
  - 1.5 Inverse and trace
2. Vector Spaces
  - 2.1 Definition
  - 2.2 Linear Combination and Linear Dependence
  - 2.3 Basis, Linear Envelope, and Rank

3. Linear and Affine Mapping
  - 3.1 Matrix Representations of Linear Mappings
  - 3.2 Image and Kernel
  - 3.3 Affine Spaces and Subspaces
  - 3.4 Affine Mapping
4. Analytical Geometry
  - 4.1 Norm
  - 4.2 Scalar Product
  - 4.3 Orthogonal Projections
  - 4.4 Outlook: Complex Numbers
5. Matrix Decomposition
  - 5.1 Determinant
  - 5.2 Eigenvalues and Eigenvectors
  - 5.3 Cholesky Decomposition
  - 5.4 Eigenvalue Decomposition and Diagonalisation
  - 5.5 Singular Value Decomposition

**Literature****Compulsory Reading****Further Reading**

- Mathai, A. M., & Haubold, H. J. (2017). Linear algebra, a course for physicists and engineers (1st ed.) De Gruyter.
- Neri, F. (2019). Linear algebra for computational sciences and engineering (2nd ed.) Springer.
- Shilov, G. E. (1977). Linear algebra. Dover Publications.
- Strang, G. (2020). Introduction to linear algebra. (5th ed.) Cambridge Press.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
----------------------------------	-------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
------------------------------------------	--------------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Fundamentals of Physics

Module Code: DLBWINGP\_E

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	None	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
1. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Christian Magnus (Fundamentals of Physics)

### Contributing Courses to Module

- Fundamentals of Physics (DLBWINGP01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Mechanics
- Thermodynamic Basics
- Electricity Theory and Electric Fields
- Vibration Theory
- Optics & Acoustics
- Introduction to Particle Physics

**Learning Outcomes****Fundamentals of Physics**

On successful completion, students will be able to

- explain the basic concepts of mechanics and calculate the quantities of mechanics.
- explain the basic concepts of thermodynamics and calculate the quantities of thermodynamics.
- apply the physical laws of electricity to electrostatic and magnetic fields.
- explain free and forced oscillations and reproduce applications.
- explain phenomena of geometrical optics and wave optics.
- understand basic concepts of particle physics.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field



# Fundamentals of Physics

Course Code: DLBWINGP01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

## Course Description

Basic principles of physics form the foundation of many engineering applications. The basic principles of mechanics, thermodynamics, and electricity, for example, are implemented in almost all technical products and are considered in their design. The course provides a broad overview of the fundamentals of physics starting from the axioms of mechanics, thermodynamic principles, electricity theory, vibration theory, optics and acoustics up to modern aspects of physics in the context of atomic physics and nuclear physics. Thus, the course provides students with an overview of the various subfields of physics and an introduction to scientific problem-solving techniques.

## Course Outcomes

On successful completion, students will be able to

- explain the basic concepts of mechanics and calculate the quantities of mechanics.
- explain the basic concepts of thermodynamics and calculate the quantities of thermodynamics.
- apply the physical laws of electricity to electrostatic and magnetic fields.
- explain free and forced oscillations and reproduce applications.
- explain phenomena of geometrical optics and wave optics.
- understand basic concepts of particle physics.

## Contents

1. Introduction
  - 1.1 Physics Overview
  - 1.2 Physical Quantities and Units
2. Mechanics
  - 2.1 Forces and Mechanics of Rigid Bodies
  - 2.2 Elastostatics
  - 2.3 The Basic Laws of Classical Mechanics
  - 2.4 Kinematics and Kinetics
  - 2.5 Impulse, Work, and Energy
  - 2.6 Fluid Mechanics

3. Thermodynamics
  - 3.1 Heat and Temperature
  - 3.2 First Law of Thermodynamics and Enthalpy
  - 3.3 Second Law of Thermodynamics and Entropy
  - 3.4 Kinetic Theory of Gases
  - 3.5 Heat: Conduction, Convection, and Radiation
4. Electricity and Magnetism
  - 4.1 Voltage, Current, and Resistance
  - 4.2 Analysis of Direct Current Networks
  - 4.3 Electrostatic Fields
  - 4.4 Magnetic Fields
  - 4.5 Alternating Current Quantities and Circuits
5. Vibration Theory and Waves
  - 5.1 Free Oscillations
  - 5.2 Forced Oscillations
  - 5.3 Waves
  - 5.4 Doppler Effect
  - 5.5 Interference
6. Optics & Acoustics
  - 6.1 Basic Terms
  - 6.2 Reflection and Refraction
  - 6.3 Radiation Optical Images and Aberrations
  - 6.4 Wave Optics - Interference and Polarization
  - 6.5 Sound Waves - Fundamentals of Acoustics
7. Introduction to Particle Physics
  - 7.1 Atomic Models in Historical Overview
  - 7.2 The Periodic Table of Elements
  - 7.3 Quantum Optics
  - 7.4 Nuclear Fission and Fusion
  - 7.5 Radioactive Radiation and X-Rays

**Literature****Compulsory Reading****Further Reading**

- Knight, R. D. (2016). Physics for scientists and engineers : a strategic approach with modern physics. Pearson Education.
- Ohanian, H. C., Markert, J. T., & Ohanian, H. C. (2007). Physics for engineers and scientists (3rd ed.). W.W. Norton.
- Walker, J., Halliday, D., & Resnick, R. (2020). Halliday & Resnick's Principles of Physics (11th ed.). Wiley.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Introduction to the Internet of Things

Module Code: DLBINGEIT\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 1. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Prof. Dr. Marian Benner-Wickner (Introduction to the Internet of Things)

### Contributing Courses to Module

- Introduction to the Internet of Things (DLBINGEIT01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

Study Format: myStudies  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Internet of Things Fundamentals
- Social and Economic Significance
- Communication Standards and Technologies
- Data Storage and Processing
- Design and Development
- Applicability

**Learning Outcomes****Introduction to the Internet of Things**

On successful completion, students will be able to

- grasp the distinctive features of Internet of Things (IoT) and IoT systems.
- understand the social and economic importance of Internet of Things.
- identify the most important standards for communication between IoT devices.
- differentiate between various techniques for storing and processing data in IoT systems.
- identify different architectures and technologies for structuring IoT systems.
- recognize challenges of data protection and data security in IoT systems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Computer Science & Software

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology fields

# Introduction to the Internet of Things

Course Code: DLBINGEIT01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

The aim of this course is to give students an insight into technical and theoretical basics of the Internet of Things (IoT) and its fields of application. In addition to the general structure of IoT systems and the technology standards used in them, students are also taught the importance of Internet of Things for economy and society. Furthermore, this course demonstrates how data is exchanged, stored and processed in IoT.

## Course Outcomes

On successful completion, students will be able to

- grasp the distinctive features of Internet of Things (IoT) and IoT systems.
- understand the social and economic importance of Internet of Things.
- identify the most important standards for communication between IoT devices.
- differentiate between various techniques for storing and processing data in IoT systems.
- identify different architectures and technologies for structuring IoT systems.
- recognize challenges of data protection and data security in IoT systems.

## Contents

1. Internet of Things Fundamentals
  - 1.1 The Internet of Things - Basics and Motivation
  - 1.2 Evolution of the Internet - Web 1.0 to Web 4.0
2. Social and Economic Significance
  - 2.1 Innovations for Consumers and Industry
  - 2.2 Implications on People and the World of Work
  - 2.3 Data Protection and Data Security
3. Communication Standards and Technologies
  - 3.1 Network Topologies
  - 3.2 Network Protocols
  - 3.3 Technologies

4. Data Storage and Processing
  - 4.1 Networked Storage with Linked Data and RDF(S)
  - 4.2 Analysis of Networked Data using a Semantic Reasoner
  - 4.3 Processing of Data Streams with Complex Event Processing
  - 4.4 Operation and Analysis of Large Data Clusters using NoSQL and MapReduce
5. Design and Development
  - 5.1 Software Engineering for Distributed and Embedded Systems
  - 5.2 Architectural Patterns and Styles for Distributed Systems
  - 5.3 Platforms: Microcontrollers, Monoboard Computers, One-Chip Systems
6. Applicability
  - 6.1 Smart Home / Smart Living
  - 6.2 Ambient Assisted Living
  - 6.3 Smart Energy / Smart Grid
  - 6.4 Smart Factory
  - 6.5 Smart Logistics

**Literature****Compulsory Reading****Further Reading**

- Firouzi, F., Chakrabarty, K., & Nassif, S. (2020). Intelligent Internet of Things: From device to fog and cloud. Springer.
- Hanes, D., Salgueiro, G., Grossetete, P., Barton, R., & Henry, J. (2017). IoT fundamentals: Networking technologies, protocols, and use cases for the Internet of Things. Cisco Press.



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Introduction to Computer Science

Module Code: DLBCSICS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
1. Semester	Minimum 1 semester	WiSe/SoSe	English

## Module Coordinator

Prof. Dr. Carsten Skerra (Introduction to Computer Science)

## Contributing Courses to Module

- Introduction to Computer Science (DLBCSICS01)

## Module Exam Type

### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

### Split Exam

## Weight of Module

see curriculum

## Module Contents

- Information representation
- Algorithms and data structures
- Propositional logic / Boolean algebra
- Hardware
- Networks and the internet
- Software
- Computer science as a discipline

**Learning Outcomes****Introduction to Computer Science**

On successful completion, students will be able to

- understand basic algorithms and data structures.
- apply basic constructs of propositional logic in programming.
- describe the structure of computer hardware systems.
- specify the structure and the main services of the internet.
- discuss professional conduct in computer science.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field(s) of Computer Science & Software Development.

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology field(s).

# Introduction to Computer Science

Course Code: DLBCSICS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

The goal of this course is to provide an introduction to computer science and its main concepts. It covers basic topics such as information representation and an introduction to algorithms and data structures. Propositional logic and Boolean algebra are also introduced, both of which form an important basis in computer science, e.g., for expressing conditions in programming. Furthermore, the course introduces the three main components of computing infrastructures: hardware, networks, and software. Finally, the course covers the meta level by looking at the role of computer science as a discipline as well as ethics and professional conduct.

## Course Outcomes

On successful completion, students will be able to

- understand basic algorithms and data structures.
- apply basic constructs of propositional logic in programming.
- describe the structure of computer hardware systems.
- specify the structure and the main services of the internet.
- discuss professional conduct in computer science.

## Contents

1. Basic concepts of data processing
  - 1.1 Data, information and messages
  - 1.2 Software, firmware and hardware
  - 1.3 Languages, syntax and semantics
  - 1.4 Historical overview
2. Information representation
  - 2.1 Number representation formats
  - 2.2 Representation of non-numerical information
  - 2.3 Data types
  - 2.4 Redundancy and error tolerance

3. Algorithms and data structures
  - 3.1 Algorithms and flow diagrams
  - 3.2 Simple data structures
  - 3.3 Searching and sorting
  - 3.4 Quality of algorithms (correctness, termination, efficiency/complexity)
4. Propositional logic, Boolean algebra and circuit design
  - 4.1 Propositions and logical conclusions
  - 4.2 Conjunctive and disjunctive normal form
  - 4.3 Digital circuit design
5. Hardware and computer architectures
  - 5.1 Computer types and their architecture
  - 5.2 Processors and memory
  - 5.3 Input and output
  - 5.4 Interfaces and drivers
  - 5.5 High-performance computing
6. Networks and the internet
  - 6.1 Wired and wireless networks and their topologies
  - 6.2 The TCP/IP and the ISO/OSI model
  - 6.3 Internet structure and services
  - 6.4 The internet of things
7. Software
  - 7.1 BIOS and operating systems
  - 7.2 Application software and information systems
  - 7.3 Apps
  - 7.4 Embedded systems
  - 7.5 Software development
8. Computer Science as a discipline
  - 8.1 The role and sub-disciplines of computer science
  - 8.2 Artificial intelligence, data science and computer science
  - 8.3 Ethical aspects of computer science
  - 8.4 The ACM Code of Ethics and Professional Conduct

**Literature****Compulsory Reading****Further Reading**

- Dale, N., & Lewis, J. (2020). Computer science illuminated (7th ed.). Jones & Bartlett Learning.
- Downey, A. B., & Mayfield, C. (2020). Think Java: How to think like a computer scientist. O'Reilly.
- Filho, W. F. (2018). Computer science distilled: Learn the art of solving computational problems. Code Energy LLC.
- Petzold, C. (2000). Code: The hidden language of computer hardware and software. Microsoft Press.
- Whittington, J. (2016). A machine made this book: Ten sketches of computer science. Coherent Press.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBCSICS01





## 2. Semester

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## Fundamentals of Chemistry

Module Code: DLBMETGC\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> None	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 2. Semester	<b>Duration</b> Minimaldauer: 1 Semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Prof. Dr. Moritz Venschott (Fundamentals of Chemistry)

### Contributing Courses to Module

- Fundamentals of Chemistry (DLBMETGC01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Atomic Structure
- Periodic Table of Elements
- Chemical Bonds
- Chemical Reactions
- Acid and Bases
- Electrochemistry
- Technical Chemistry

**Learning Outcomes****Fundamentals of Chemistry**

On successful completion, students will be able to

- understand the fundamentals and concepts of chemistry.
- answer basic theoretical and practical chemistry questions.
- describe the atomic structure.
- describe and differentiate chemical bonds.
- set up chemical reactions and balance them stoichiometrically.
- apply the law of mass action and chemical equilibrium to acids, bases, salts and buffer systems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Natural Sciences

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field



# Fundamentals of Chemistry

Course Code: DLBMETGC01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

## Course Description

The fundamentals of chemistry form the foundation of many engineering applications. To this end, the module provides a broad overview of the fundamentals of chemistry, starting from atomic structure, elementary particles, and the periodic table, to chemical bonds and reactions, as well as acids, bases, and solutions. In addition, an overview of the fundamentals of organic, inorganic, physical and technical chemistry is provided. Thus, the course provides students with an overview of the various branches of chemistry and an introduction to scientific problem-solving techniques.

## Course Outcomes

On successful completion, students will be able to

- understand the fundamentals and concepts of chemistry.
- answer basic theoretical and practical chemistry questions.
- describe the atomic structure.
- describe and differentiate chemical bonds.
- set up chemical reactions and balance them stoichiometrically.
- apply the law of mass action and chemical equilibrium to acids, bases, salts and buffer systems.

## Contents

1. Atomic Structure and Elementary Particles
  - 1.1 Pure Substances and Mixtures
  - 1.2 Aggregate States
  - 1.3 Structure of Atoms from Elementary Particles
  - 1.4 Bohr's Atomic Model
  - 1.5 Orbital Model
2. Periodic Table of Elements
  - 2.1 Elements of the Periodic Table
  - 2.2 Structure of the Periodic Table
  - 2.3 Electron Configuration
  - 2.4 Isotopes and Nuclides

3. Chemical Bond
  - 3.1 Ionic Bond
  - 3.2 Covalent Bond
  - 3.3 Metallic Bond
  - 3.4 Intermolecular Forces
4. Chemical Reactions
  - 4.1 Reaction Equations
  - 4.2 Stoichiometry
  - 4.3 Energy Changes in Reactions
  - 4.4 Chemical Equilibrium
  - 4.5 Catalysis
5. Acids and Bases
  - 5.1 Acid-Base Concepts
  - 5.2 Acid Strength and the pH Value
  - 5.3 Dilution and Neutralization
6. Solutions
  - 6.1 Solubility
  - 6.2 Solubility Product
7. Fundamentals of Organic and Inorganic Chemistry
  - 7.1 Organic Compounds
  - 7.2 Functional Groups
  - 7.3 Nomenclature
  - 7.4 Reaction Types
  - 7.5 Inorganic Chemistry
8. Basics of Electrochemistry
  - 8.1 Oxidation, Reduction, Redox Systems
  - 8.2 Electrochemical and Galvanic Cell
  - 8.3 Batteries and Accumulators
  - 8.4 Fuel Cells
  - 8.5 Electrolysis and Electroplating

9. Technical Chemistry
  - 9.1 Chemical Processes and Chemical Industry
  - 9.2 Chemical Reaction Engineering
  - 9.3 Basic Operations
  - 9.4 Process Development

**Literature****Compulsory Reading****Further Reading**

- Agarwal, S. (2019). Engineering Chemistry Fundamentals and Applications. Journal of Chemical Information and Modeling (2nd ed.). Cambridge University Press.
- Daneş, F. E., Daneş, S., Petrescu, V., & Ungureanu, E.-M. (2021). Molecular Physical Chemistry for Engineering Applications. Molecular Physical Chemistry for Engineering Applications. Springer International Publishing. <https://doi.org/10.1007/978-3-030-63896-2>
- Savitskaya, T., Kimlenka, I., Lu, Y., Hrynshpan, D., Sarkisov, V., Yu, J., ... Wang, L. (2021). Green Chemistry. Singapore: Springer Singapore. <https://doi.org/10.1007/978-981-16-3746-9>

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Production Engineering

Module Code: DLBDSEAR1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
2. Semester	Minimum 1 semester	WiSe/SoSe	English

## Module Coordinator

Prof. Dr. Mario Boßlau (Production Engineering)

## Contributing Courses to Module

- Production Engineering (DLBDSEAR01)

## Module Exam Type

### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

### Split Exam

## Weight of Module

see curriculum

## Module Contents

- Introduction to Manufacturing Technology
- Main Production Groups According to DIN 8580
- Additive Manufacturing Processes
- Rapid Prototyping
- Rapid Tooling
- Direct/Rapid Manufacturing
- Cyber-Physical Production Plants

**Learning Outcomes****Production Engineering**

On successful completion, students will be able to

- understand the basic concepts and interrelationships of production engineering.
- understand current changes in manufacturing technology due to technologies such as additive manufacturing and megatrends such as cyber physical systems.
- assign different manufacturing processes to the main manufacturing groups according to DIN 8580.
- understand the basic principle of additive manufacturing processes.
- distinguish between different additive manufacturing processes.
- understand the terms Rapid Prototyping, Rapid Tooling, and Direct Manufacturing and name individual processes and application examples.
- understand the elements and properties of cyber-physical production plants.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Computer Science & Software Development

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields

# Production Engineering

Course Code: DLBDSEAR01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

The aim of the course is to provide students with an overview of the processes that have influenced and still influence production processes through technological developments under the generic term Industry 4.0, based on traditional, standardized manufacturing techniques. These include, in particular, technological advances in additive manufacturing processes that enable applications such as rapid prototyping, rapid tooling, and direct manufacturing. Finally, the course deals with the consequences of the digitalization and networking of production facilities and their elements in the sense of a cyber-physical system.

## Course Outcomes

On successful completion, students will be able to

- understand the basic concepts and interrelationships of production engineering.
- understand current changes in manufacturing technology due to technologies such as additive manufacturing and megatrends such as cyber physical systems.
- assign different manufacturing processes to the main manufacturing groups according to DIN 8580.
- understand the basic principle of additive manufacturing processes.
- distinguish between different additive manufacturing processes.
- understand the terms Rapid Prototyping, Rapid Tooling, and Direct Manufacturing and name individual processes and application examples.
- understand the elements and properties of cyber-physical production plants.

## Contents

1. Introduction to Manufacturing Technology
  - 1.1 Basic Terms and Contexts in Manufacturing Theory
  - 1.2 Historical Development of Production
  - 1.3 The Discussion About the Long Tail

2. Classification Of Manufacturing Processes
  - 2.1 Casting and Molding
  - 2.2 Forming
  - 2.3 Machining
  - 2.4 Joining
  - 2.5 Coating
  - 2.6 Changing the Properties of Substances
3. Additive Manufacturing Processes
  - 3.1 Basic Principles and Legal Aspects
  - 3.2 Stereolithography (STL)
  - 3.3 Selective Laser Sintering and Selective Beam Melting With Laser or Electron Beam
  - 3.4 Fused Deposition Modeling (FDM)
  - 3.5 Multi-Jet Modeling (MJM) and Poly-Jet Process (PJM)
  - 3.6 3D Printing Process (3DP)
  - 3.7 Laminating Processes
  - 3.8 Mask Sintering
4. Rapid Prototyping
  - 4.1 Definition
  - 4.2 Strategic and Operational Aspects
  - 4.3 Application Areas and Examples
5. Rapid Tooling
  - 5.1 Definition, Strategic, and Operational Aspects
  - 5.2 Indirect and Direct Procedures
6. Direct/Rapid Manufacturing
  - 6.1 Potentials and Requirements for Procedures
  - 6.2 Implementation, Application Areas, and Examples
7. Cyber-Physical Production Plants
  - 7.1 Derivation of the Terms Industry 4.0 and Cyber-Physical Systems
  - 7.2 Megatrend Cyber Physical Systems (CPS)
  - 7.3 Definition Cyber-Physical Production Plant
  - 7.4 Effects on Planning and Operation of Production Facilities
  - 7.5 Dynamic Reconfiguration and Migration of Production Facilities



**Literature****Compulsory Reading****Further Reading**

- Anderson, C. (2012): Makers. The new industrial revolution. Crown Business, New York.
- Gebhardt, A. (2012): Understanding Additive Manufacturing. Rapid Prototyping – Rapid Tooling – Rapid Manufacturing. Hanser, München/Cincinnati.
- Gibson, I., Rosen, D., Stucker, B., & Khorasani, M. (2021). Additive Manufacturing Technologies (3rd ed.). Springer International Publishing.
- Groover, M. P., (2019). Fundamentals of Modern Manufacturing: Materials, Processes, and Systems (7th ed.). Wiley.
- Kalpakjian, S., & Schmid, S.R. (2020). Manufacturing Engineering and Technology (8th ed.). Pearson.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBDSEAR01

## Mechanics - Statics

Module Code: DLBROMS\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 2. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Prof. Dr. Torsten Bruns (Mechanics - Statics)

### Contributing Courses to Module

- Mechanics - Statics (DLBROMS01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

Study Format: myStudies  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Bearing reactions
- Balance conditions
- Determinancy
- Structure
- Mechanics

**Learning Outcomes****Mechanics - Statics**

On successful completion, students will be able to

- calculate bearing reactions.
- describe the most important terms of statics and the static determination of systems.
- understand the importance of systems of forces on supporting structures.
- describe and calculate static processes through balance conditions.
- determine balance points.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields

## Mechanics - Statics

Course Code: DLBROMS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

In this course, participants will get an overview of the importance of systems of forces, frameworks and supporting structures and learn the basics of their calculation and corresponding methods. Students will learn to transform technical systems into suitable mechanical replacement models. Further, using balance conditions, students will be able to specify a complete load state on rigid systems by means of clearance cutting. Students can independently check systems for static determination. They can independently calculate bar forces of planar frameworks following diverse methods. Furthermore, students are able to calculate inner component load of simple mechanical systems by means of internal force variables. They can interpret stress values and independently evaluate the component load. Finally, limitations in rigid body statics are discussed.

### Course Outcomes

On successful completion, students will be able to

- calculate bearing reactions.
- describe the most important terms of statics and the static determination of systems.
- understand the importance of systems of forces on supporting structures.
- describe and calculate static processes through balance conditions.
- determine balance points.

### Contents

1. Basic Physical Quantities, Vectors
  - 1.1 Physical Quantities, Units
  - 1.2 Newton's Basic Axioms
  - 1.3 Scalars, Position and Force Vectors
  - 1.4 Vector Operations

2. Static Equilibrium
  - 2.1 Equilibrium of Particles
  - 2.2 Moment
  - 2.3 Center of Gravity
  - 2.4 Equilibrium of Rigid Bodies
  - 2.5 Bearing Types, Static Determinacy
3. Planar Trusses
  - 3.1 Simple Triangular Trusses
  - 3.2 Analysis Using Methods of Joints
  - 3.3 Analysis Using Method of Sections
  - 3.4 The Principle of Virtual Work
4. Internal Forces
  - 4.1 Center of Areas, Moment of Inertia
  - 4.2 Beam Internal Loading
  - 4.3 Beams with Different Support Conditions
5. Solid State Friction
  - 5.1 Static Friction
  - 5.2 Sliding Friction
  - 5.3 Rolling Friction

**Literature****Compulsory Reading****Further Reading**

- Assmann, B./Selke, P. (2009): Technische Mechanik 1. Statik. 19. Auflage, Oldenbourg Verlag, München.
- Gross, D. et al. (2019): Technische Mechanik 1. Statik. Springer Vieweg Verlag, Wiesbaden.
- Holzmann G./Meyer, H./Schumpich, G. (2009): Technische Mechanik. Statik. 12. Auflage, Vieweg +Teubner Verlag, Wiesbaden.



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Automation Technology

Module Code: DLBROEIRA2\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 2. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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## Module Coordinator

N.N. (Automation Technology)

## Contributing Courses to Module

- Automation Technology (DLBROEIRA02\_E)

## Module Exam Type

### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

Study Format: myStudies  
Exam, 90 Minutes

### Split Exam

## Weight of Module

see curriculum

## Module Contents

- Modern automation systems
- Programmable logic controllers
- Batch automation
- SCADA
- Industrial communications
- Distributed control systems
- Cyber-security

**Learning Outcomes****Automation Technology**

On successful completion, students will be able to

- understand modern automation systems.
- identify trends and challenges.
- design an industrial automation system for an application.
- name relevant cyber-security issues.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields

# Automation Technology

Course Code: DLBROEIRA02\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Automation technology refers to the analysis, design and improvement of existing or new automation systems. Modern automation systems are characterized by the combination of many different devices, such as actuators, sensors, machines, which must be able to perform a coordinate action and to exchange data with each other. This course introduces such modern automation systems by listing their necessary components, presenting current challenges and trends and explaining communication technologies to build effective industrial automation networks. A brief overview on the topic of cyber-security is also given.

## Course Outcomes

On successful completion, students will be able to

- understand modern automation systems.
- identify trends and challenges.
- design an industrial automation system for an application.
- name relevant cyber-security issues.

## Contents

1. Introduction
  - 1.1 Evolution of Automation
  - 1.2 Industrial Revolutions
  - 1.3 Modern Automation Systems
  - 1.4 Challenges and Trends
2. An Introduction to Programmable Logic Controllers
  - 2.1 Hardware
  - 2.2 Internal Architecture
  - 2.3 I/O
  - 2.4 Ladder and Functional Block Programming
  - 2.5 Programming Methods

3. Batch Automation
  - 3.1 Basics
  - 3.2 Applications
4. SCADA Systems
  - 4.1 Overview
  - 4.2 Components
  - 4.3 Communication Technologies
  - 4.4 Interfaces
5. Industrial Communication Technologies
  - 5.1 Industrial Networks
  - 5.2 HART
  - 5.3 PROFIBUS
  - 5.4 Wireless Communication
  - 5.5 OPC
  - 5.6 Konnex (EIB/KNX)
  - 5.7 LonWorks®
6. Distributed Control System
  - 6.1 Evolution of Control Systems
  - 6.2 Components of Distributed Control Systems
7. Cyber Security in Industrial Automation
  - 7.1 Plant Control Network
  - 7.2 Cyber Attacks
  - 7.3 Common Industrial Software Weaknesses

**Literature****Compulsory Reading****Further Reading**

- Gupta, A. K./Arora, S. K./Westcott, J. R. (2016): Industrial automation and robotics. Mercury Learning & Information, Herndon, VA.
- Mehta, B. R./Reddy, Y. J. (2014): Industrial process automation systems: Design and implementation. Elsevier Inc, Amsterdam.
- Merz, H./Hansemann, T./Hübner, C. (2018): Building Automation. Springer International Publishing, Cham.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



## Mathematics: Analysis

Module Code: DLBDSMFC

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 2. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Prof. Dr. Robert Graf (Mathematics: Analysis)

### Contributing Courses to Module

- Mathematics: Analysis (DLBDSMFC01)

### Module Exam Type

#### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Sequences and series
- Functions & reverse functions
- differential calculus
- integral calculus

**Learning Outcomes****Mathematics: Analysis**

On successful completion, students will be able to

- summarize the basic concepts of analysis.
- illustrate the terms "consequences" and "series".
- explain the concept of function and to understand the concept of the inverse function.
- explain basic statements of the differential and integral calculus.
- explain the relationship between differentiation and integration.
- master the derivation of higher-dimensional functions.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Methods

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology fields

# Mathematics: Analysis

Course Code: DLBDSMFC01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Analysis is one of the essential basic subjects of mathematics. Originally developed to be able to formulate and solve problems of classical mechanics mathematically, in its present rigorous form it has become indispensable in numerous applications in the natural sciences and technology. This module aims to introduce the basic hand tool of differential and integral calculus and to explain their mutual interrelations. In addition, the differential calculus is generalized to multidimensional spaces.

## Course Outcomes

On successful completion, students will be able to

- summarize the basic concepts of analysis.
- illustrate the terms "consequences" and "series".
- explain the concept of function and to understand the concept of the inverse function.
- explain basic statements of the differential and integral calculus.
- explain the relationship between differentiation and integration.
- master the derivation of higher-dimensional functions.

## Contents

1. Sequences and series
  - 1.1 Sequences and series
  - 1.2 Convergence of infinite series
  - 1.3 power series
2. Functions and reverse functions
  - 2.1 Continuous functions
  - 2.2 Exponential and logarithm function
  - 2.3 Trigonometric functions and their inverse functions

3. Differential calculus
  - 3.1 Derivatives and higher derivatives
  - 3.2 curve discussion
  - 3.3 Rules (chain rule, product rule, quotient rule ...)
  - 3.4 Taylor Rows
4. Integral calculus
  - 4.1 The Riemann Integral
  - 4.2 Specific and indefinite integrals
  - 4.3 The fundamental theorem of differential and integral calculus
  - 4.4 Volumes and shells of rotary bodies
  - 4.5 Paths and lengths
5. Differential calculus in the  $\mathbb{R}^n$ 
  - 5.1 Partial Derivation
  - 5.2 Total Derivation
  - 5.3 Gradients of vector-valued functions and matrices

**Literature****Compulsory Reading****Further Reading**

- Deisenroth, M.P., Faisal, A.A., & Ong, C.S. (2020). Mathematics for Machine Learning. Cambridge University Press.
- Magnus, R. (2020). Fundamental Mathematical Analysis. Springer International Publishing.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
------------------------------------------	--------------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Signals and Systems

Module Code: DLBROSS\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 2. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Signals and Systems)

### Contributing Courses to Module

- Signals and Systems (DLBROSS01\_E)

### Module Exam Type

#### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Introduction to systems and signals
- Time-domain analysis of continuous-time systems
- Continuous-time system analysis using the Laplace Transform
- Continuous-time signal analysis: The Fourier Series and the Fourier Transform
- Sampling

**Learning Outcomes****Signals and Systems**

On successful completion, students will be able to

- classify systems and signals.
- analyze properties and solve problems involving systems and inputs.
- use the Laplace Transform to analyze linear time-invariant systems.
- apply the Fourier Series and Fourier Transform to analyze periodic and aperiodic signals.
- calculate measures of systems and signals, e.g. signal energy.
- understand sampling.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields



# Signals and Systems

Course Code: DLBROSS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

From a mathematical perspective almost everything can be seen and analyzed as being a system, i.e. a unit that processes signals and information and generates signals and information. This course provides the mathematical basics on signals and systems, with a particular emphasis on continuous time. In the first part, the mathematical preliminaries are given, and a classification of signals and systems is presented. The time-domain analysis is introduced, discussing how systems respond to external inputs and their internal conditions. To analyze systems and signals, however, further tools such as the Laplace Transform and the Fourier Series and Transform are widely implemented, because they give useful insights, especially into frequency behavior. The bridge between continuous-time and discrete time systems and signals, i.e. sampling, is also discussed.

## Course Outcomes

On successful completion, students will be able to

- classify systems and signals.
- analyze properties and solve problems involving systems and inputs.
- use the Laplace Transform to analyze linear time-invariant systems.
- apply the Fourier Series and Fourier Transform to analyze periodic and aperiodic signals.
- calculate measures of systems and signals, e.g. signal energy.
- understand sampling.

## Contents

1. Introduction to Systems and Signals
  - 1.1 Classification of Signals
  - 1.2 Signal Operations
  - 1.3 Classification of Systems
  - 1.4 System Models
2. Time-Domain Analysis of Continuous-Time Systems
  - 2.1 System Response to Internal Conditions and External Input
  - 2.2 System Stability

3. Continuous-Time System Analysis Using the Laplace Transform
  - 3.1 The Laplace Transform
  - 3.2 The Inverse Laplace Transform
  - 3.3 Solution of Differential Equations
  - 3.4 Block Diagrams
  - 3.5 Applications to Systems
4. Continuous-Time Signal Analysis: The Fourier Series and The Fourier Transform
  - 4.1 The Fourier Series
  - 4.2 The Fourier Transform
  - 4.3 Properties
  - 4.4 Signal Energy
  - 4.5 Applications
5. Sampling
  - 5.1 The Discrete-time Fourier Transform and the Sampling Theorem
  - 5.2 Signal Reconstruction
  - 5.3 Analog to Digital Conversion
  - 5.4 Spectral Sampling
  - 5.5 An Introduction to the Discrete and Fast Fourier Transforms

**Literature****Compulsory Reading****Further Reading**

- Alkin, O. (2014): Signals and systems: a MATLAB integrated approach. CRC Press, Boca Raton, FL.
- Lathi, B. P. (2009): Principles of Linear Systems and Signals. 2nd ed., Oxford University Press, New Delhi.
- Rao, K. D. (2018): Signals and Systems. Springer International Publishing, Cham.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
------------------------------------------	--------------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides





# 3. Semester

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## Control Systems Engineering

Module Code: DLBROCSE\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> DLBROSS01_E	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 3. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Control Systems Engineering)

### Contributing Courses to Module

- Control Systems Engineering (DLBROCSE01\_E)

### Module Exam Type

#### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

**Module Contents**

- Introduction to control systems
- Modeling in the frequency domain
- Time response
- Stability
- Steady-state errors
- The root locus
- The frequency response
- Design via frequency response

**Learning Outcomes****Control Systems Engineering**

On successful completion, students will be able to

- understand the components of a control system.
- analyze properties of systems in time and frequency domains.
- define dynamic and static requirements in time and frequency domains.
- analyze the stability of dynamic systems.
- understand and calculate the frequency-response of systems.
- design standard feedback controllers to achieve target performance.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields

# Control Systems Engineering

Course Code: DLBROCSE01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBROSS01_E

## Course Description

Control systems are an integral part of modern society. They are omnipresent in mechatronics, robotics, production engineering, manufacturing processes, and medical technology. A control system is made of subsystems and processes assembled for the purpose of obtaining a desired output with desired performance, given a specified input. Control systems engineering is the discipline which analyzes systems, intended to enable the design of controllers which ensure the desired performance. This course introduces the concept of control systems and provides further understanding of systems in terms of their dynamical properties. In particular, the frequency-domain description of systems, given by the application of the Laplace Transform, is used to gain qualitative and quantitative insights into the behavior of linear time-invariant systems. The concept of frequency response is introduced in detail and is used to allow for the design of linear time-invariant feedback controllers to reach the desired performance.

## Course Outcomes

On successful completion, students will be able to

- understand the components of a control system.
- analyze properties of systems in time and frequency domains.
- define dynamic and static requirements in time and frequency domains.
- analyze the stability of dynamic systems.
- understand and calculate the frequency-response of systems.
- design standard feedback controllers to achieve target performance.

## Contents

1. Introduction to Control Systems
  - 1.1 Introduction and History
  - 1.2 Open-loop and Closed-loop Systems
  - 1.3 Design Objectives
  - 1.4 The Design Process
  - 1.5 Trends in Control Systems

2. Modeling in the Frequency Domain
  - 2.1 Laplace and Inverse Laplace Transform
  - 2.2 The Transfer Function
  - 2.3 Nonlinearities and Linearization
  - 2.4 Algebra of Block Diagrams
  - 2.5 Examples
3. Time Response
  - 3.1 Poles and Zeros
  - 3.2 First-order Systems
  - 3.3 Second-order Systems
  - 3.4 Higher-order Systems
  - 3.5 Effects of Nonlinearities
4. Stability
  - 4.1 Introduction to Stability
  - 4.2 Stability Criteria
5. Steady-state Errors
  - 5.1 Unity Feedback Systems
  - 5.2 Static Error Constants
  - 5.3 Steady-state Error Specifications
  - 5.4 Disturbances
  - 5.5 Non-unity Feedback Systems
  - 5.6 Sensitivity
6. The Root Locus
  - 6.1 Definition and Properties
  - 6.2 Sketching the Root Locus
  - 6.3 Design via Root Locus
7. The Frequency Response
  - 7.1 Introduction
  - 7.2 The Bode Plot
  - 7.3 The Nyquist Diagram
  - 7.4 Stability, Gain and Phase Margins

8. Design via Frequency Response
  - 8.1 Transient Response via Gain Adjustment
  - 8.2 PI Compensation
  - 8.3 Lag Compensation
  - 8.4 PD Compensation
  - 8.5 Lead Compensation
  - 8.6 Lead-Lag Compensation and PID compensation
  - 8.7 Design Limitations
  - 8.8 Time-Delay

**Literature****Compulsory Reading****Further Reading**

- Nise, N. S. (2019): Control systems engineering. 8th ed., John Wiley & Sons, Hoboken, NJ.
- Doyle, J. C./Francis, B. A./Tannenbaum, A. R. (2009): Feedback Control Theory. Dover Publications Inc, Mineola, NY.
- Franklin, G. F./Powell, J. D./Emami-Naeini, A. (2019): Feedback control of dynamic systems. 8th ed., Pearson, London.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBROCSE01\_E



# Materials Science for Engineers

Module Code: DLBMETGWK\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> None	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 3. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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## Module Coordinator

N.N. (Materials Science for Engineers)

## Contributing Courses to Module

- Materials Science for Engineers (DLBMETGWK01\_E)

## Module Exam Type

### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

### Split Exam

## Weight of Module

see curriculum

## Module Contents

- Introduction to Materials Science
- Structure of Materials
- Properties of Materials
- Material Classes: Metals, Ceramics, Polymers and Composites
- Application of Engineering Materials

**Learning Outcomes**

**Materials Science for Engineers**

On successful completion, students will be able to

- understand basic relationships between microscopic and macroscopic processes and properties.
- understand the main differences and properties of the four classes of materials: metals, ceramics, polymers, and composites.
- use the properties of the material classes in material selection and application.
- consider common mechanisms that lead to the failure of materials.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Natural Sciences

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field

# Materials Science for Engineers

Course Code: DLBMETGWK01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

## Course Description

The course Material Science for Engineers gives an overview of the four material classes: metals, ceramics, polymers, and composites. Beginning with the microscopic structure of materials, the resulting mechanical, non-mechanical physical and chemical properties are considered. This knowledge gives the foundation for engineering use, enabling students to understand and actively design the lifecycle of materials from acquisition of raw materials through selection and use to end-of-life management. As a conclusion, examples and additional information are given from the fields of medical technology, mechanical engineering, electrical engineering, mechatronics, and robotics.

## Course Outcomes

On successful completion, students will be able to

- understand basic relationships between microscopic and macroscopic processes and properties.
- understand the main differences and properties of the four classes of materials: metals, ceramics, polymers, and composites.
- use the properties of the material classes in material selection and application.
- consider common mechanisms that lead to the failure of materials.

## Contents

1. Introduction to Materials Science and Engineering
  - 1.1 Subject and Meaning
  - 1.2 Basic Consideration of Material Properties
  - 1.3 Requirements for Materials
2. Structure and Classes of Materials
  - 2.1 Atomic Structure and Chemical Bonding
  - 2.2 Metals
  - 2.3 Ceramics
  - 2.4 Polymers
  - 2.5 Composites
  - 2.6 Basics of Heat Treatment

3. Mechanical Properties
  - 3.1 Mechanical Stress
  - 3.2 Elasticity
  - 3.3 Plasticity
  - 3.4 Creep
  - 3.5 Fracture
4. Non-Mechanical Physical Properties
  - 4.1 Electrical Properties
  - 4.2 Magnetic Properties
  - 4.3 Thermal Conductivity
  - 4.4 Optical Properties
  - 4.5 Thermal Expansion
  - 4.6 Overview of Other Physical Properties
5. Chemical and Tribological Properties
  - 5.1 Surfaces and Failure of Materials
  - 5.2 Electrochemical Corrosion
  - 5.3 Stress Corrosion Cracking
  - 5.4 Friction and Wear
6. Application of Engineering Materials
  - 6.1 Influence of Production on Material Properties
  - 6.2 Testing, Standardization and Designation
  - 6.3 Material Selection
  - 6.4 Recycling
7. Domain-Specific Additions and Examples
  - 7.1 Medical Technology
  - 7.2 Mechanical Engineering
  - 7.3 Electrical Engineering
  - 7.4 Mechatronics
  - 7.5 Robotics

**Literature****Compulsory Reading****Further Reading**

- Brostow, W./Hagg Lobland, H. E. (2016): Materials: Introduction and Applications. Wiley.
- Callister, W. D./Rethwisch, D. G. (2018): Fundamentals of Materials Science and Engineering: An Integrated Approach. 5th Edition, Wiley.
- Wright, W./Askeland, D. (2021): The Science and Engineering of Materials, Enhanced Edition. 7th Edition, CL Engineering.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Sensor Technology

Module Code: DLBROST\_E

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
3. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Matthias Eifler (Sensor Technology)

### Contributing Courses to Module

- Sensor Technology (DLBROST01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

Study Format: myStudies  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Sensors and transducers
- Resistive, capacitive, inductive, optical and acoustic sensor effects
- Transduction platforms and sensor systems
- Applications
- Advanced sensors

**Learning Outcomes****Sensor Technology**

On successful completion, students will be able to

- understand the main sensor characteristics.
- read and understand a typical sensor data sheet.
- understand sensor effects.
- understand and characterize sensor platforms.
- select the appropriate sensor technology for a given application.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology fields



# Sensor Technology

Course Code: DLBROST01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Sensors are at the base of any modern engineering system, for example, control systems in robotics. This course provides the basic knowledge to understand sensors and their characteristics. A specific sensor is chosen for an application mainly based on its characteristics and on its physical effect. After an introduction on sensors and types of sensors, this course introduces the main characteristics such as accuracy, precision, resolution, sensitivity, linearity, static and dynamic properties. The second part of the course details the main sensor effects and shows how sensor systems can be built based on such effects and used in engineering applications. The last part of the course shows current trends and advanced applications of sensor technology.

## Course Outcomes

On successful completion, students will be able to

- understand the main sensor characteristics.
- read and understand a typical sensor data sheet.
- understand sensor effects.
- understand and characterize sensor platforms.
- select the appropriate sensor technology for a given application.

## Contents

1. Introduction to Measurement Uncertainty
  - 1.1 Measurement Uncertainty
  - 1.2 Confidence Intervals
  - 1.3 Expression of Uncertainty
2. Sensors
  - 2.1 Sensors and Transducers
  - 2.2 Selection of Sensors
  - 2.3 Sensor Characteristics
  - 2.4 Measurement Systems and Components

3. Resistive Sensors
  - 3.1 Resistivity and Resistance
  - 3.2 Potentiometric Sensors
  - 3.3 Strain Gauges
  - 3.4 Piezoresistive Sensors
  - 3.5 Magnetoresistive Sensors
  - 3.6 Thermoresistive Sensors
  - 3.7 Optoresistive Sensors
4. Capacitive Sensors
  - 4.1 Capacitance and Permittivity
  - 4.2 Configurations
  - 4.3 Applications
5. Inductive and Magnetic Sensors
  - 5.1 Magnetic and Electromagnetic Quantities
  - 5.2 Magnetic Field Sensors
  - 5.3 Magnetic Displacement and Force Sensors
  - 5.4 Applications
6. Optical Sensors
  - 6.1 Electro-Optical Components
  - 6.2 Optical Displacement Sensors
  - 6.3 Applications
7. Piezoelectric Sensors
  - 7.1 Piezoelectricity
  - 7.2 Force Pressure and Acceleration Sensors
  - 7.3 Applications
8. Acoustic Sensors
  - 8.1 Acoustic Medium
  - 8.2 Measurement Methods
  - 8.3 Applications

9. Advanced Sensor Technology
  - 9.1 Organic Sensors
  - 9.2 Sensors for Health and Environment
  - 9.3 Wearable Sensors
  - 9.4 Wireless Sensors in Industrial Environments

**Literature****Compulsory Reading****Further Reading**

- Dertien, E., & Regtien, P. (2018). *Sensors for mechatronics* (2nd ed.). Elsevier.
- Lin, Y. L., Kyung, C. M., Yasuura, H., & Liu, Y. (Eds.) (2015). *Smart sensors and systems*. Springer International.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBROST01\_E

## Electrical Engineering

Module Code: DLBINGET-01\_E

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
3. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Moustafa Nawito (Electrical Engineering)

### Contributing Courses to Module

- Electrical Engineering (DLBINGET01-01\_E)

### Module Exam Type

#### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <ul style="list-style-type: none"> <li>▪ Basic Terms</li> <li>▪ Introduction to Direct Current Technology</li> <li>▪ Calculation of Direct Current Networks</li> <li>▪ Electric Fields</li> <li>▪ Introduction to Alternating Current Technology</li> <li>▪ Calculation of Alternating Current Networks</li> <li>▪ Locus Curves</li> <li>▪ Transformers</li> <li>▪ Multiphase Systems</li> <li>▪ Transient Response</li> </ul>	
<p><b>Learning Outcomes</b></p> <p><b>Electrical Engineering</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ know the basic terms of electrical engineering.</li> <li>▪ calculate DC (direct current) circuits and networks.</li> <li>▪ know the different types of electrical fields.</li> <li>▪ calculate AC (alternating current) circuits and networks.</li> <li>▪ know methods for the construction of root locus curves.</li> <li>▪ know the basic structure of different types of transformers.</li> <li>▪ calculate equivalent circuit diagrams with transformers.</li> <li>▪ know multiphase systems and can distinguish them from single-phase systems.</li> <li>▪ measure performance in a three-phase system.</li> <li>▪ calculate the transient response with the Laplace transformation.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field of Engineering</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programmes in the IT &amp; Technology fields</p>



# Electrical Engineering

Course Code: DLBINGET01-01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

The aim of the course is to offer students a broad insight into the basics of electrical engineering. First of all, the basic terms of electrical engineering and the relevant physical quantities are introduced. This is followed by two comprehensive sections on direct current and alternating current technology. They are first briefly introduced using their essential elements and properties and then supplemented by methods for calculating the respective circuits and networks. Based on this, multi-phase systems and their application in public power supply are presented. The course concludes with a consideration of the transient response and its calculation using the Laplace transformation.

## Course Outcomes

On successful completion, students will be able to

- know the basic terms of electrical engineering.
- calculate DC (direct current) circuits and networks.
- know the different types of electrical fields.
- calculate AC (alternating current) circuits and networks.
- know methods for the construction of root locus curves.
- know the basic structure of different types of transformers.
- calculate equivalent circuit diagrams with transformers.
- know multiphase systems and can distinguish them from single-phase systems.
- measure performance in a three-phase system.
- calculate the transient response with the Laplace transformation.

## Contents

1. Basic Terms
  - 1.1 Charge, Electric Fields and Voltage
  - 1.2 Current and Resistance
  - 1.3 Electrical Energy and Power
2. Introduction to Direct Current Technology
  - 2.1 Kirchhoff's Laws
  - 2.2 Calculation of Series and Parallel Connections
  - 2.3 Voltage and Current Divider Rule

3. Calculation of Direct Current Networks
  - 3.1 Mesh-Current and Node-Voltage Method
  - 3.2 Superposition Method
  - 3.3 Wye-Delta Transformation of Circuits
  - 3.4 Examples
4. Introduction to Alternating Current Technology
  - 4.1 Electrostatic and Magnetic Fields
  - 4.2 Capacitor and Inductor
  - 4.3 Alternating Variables and their Calculation
  - 4.4 Network Analysis with Complex-Valued Variables
5. Calculation of Alternating Current Networks
  - 5.1 Simple AC Circuits and their Calculation
  - 5.2 Power Types in the AC Circuit
  - 5.3 Oscillating Circuits
  - 5.4 Examples
6. Root Locus Curves
  - 6.1 The Root Locus Concept
  - 6.2 Construction of Various Root Locus Curves
  - 6.3 Examples
7. Transformers
  - 7.1 Basic Functionality
  - 7.2 Equivalent Circuit Diagram
  - 7.3 Measurement Methods
8. Multiphase Systems
  - 8.1 Three-Phase Current Technology (Three-Phase Systems)
  - 8.2 Power Measurement in Three-Phase Systems
9. Transient Response
  - 9.1 Description of Time Dependent Processes with Differential Equations
  - 9.2 Setting up Differential Equations of Electrical Circuits
  - 9.3 Introduction to the Laplace Transformation
  - 9.4 Calculation of Transient Response

**Literature****Compulsory Reading****Further Reading**

- Hagmann, G. (2013): Grundlagen der Elektrotechnik. 16. Auflage, AULA-Verlag, Wiebelsheim.
- Scherz, P. (2016): Practical Electronics for Inventors. 4. Auflage, McGraw-Hill Education, New York.
- Weißgerber, W. (2015): Elektrotechnik für Ingenieure 1. 10. Auflage, Springer, Wiesbaden.
- Weißgerber, W. (2015): Elektrotechnik für Ingenieure 2. 9. Auflage, Springer, Wiesbaden.
- Weißgerber, W. (2015): Elektrotechnik für Ingenieure 3. 9. Auflage, Springer, Wiesbaden.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBINGET01-01\_E

## Mechanics - Kinematics and Dynamics

Module Code: DLBROMKD\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> DLBBIGTM01-01 or DLBROMS01_E	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 3. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Mechanics - Kinematics and Dynamics)

### Contributing Courses to Module

- Mechanics - Kinematics and Dynamics (DLBROMKD01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Kinematics
- Differential kinematics
- Trajectory planning
- Dynamics

**Learning Outcomes****Mechanics - Kinematics and Dynamics**

On successful completion, students will be able to

- describe the kinematics of a mass point, rigid body and multibody systems.
- describe the kinetics of a mass point and rigid body.
- differentiate and describe collision processes.
- model the dynamics of multibody systems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields



# Mechanics - Kinematics and Dynamics

Course Code: DLBROMKD01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBBIGTM01-01 or DLBROMS01_E

## Course Description

Mechanical Engineering applies physical principles to technical systems and represents a fundamental discipline in engineering sciences. In addition to Statics and Elastostatics modules, the modules Kinematics and Dynamics enrich the engineering mechanics lecture series. Using kinematics, which deals with the motion of mass points and rigid bodies without addressing the cause of the motion, the foundation of kinetics is taught. Kinetics in turn describes the change of motion quantities under the influence of forces. Based on that, collision processes and associated specific momentum changes are described. Furthermore, the concept of mechanical oscillation is introduced. In this course, both the kinematic aspect (change of motion quantities) and the kinetic aspect (forces and moments) are treated.

## Course Outcomes

On successful completion, students will be able to

- describe the kinematics of a mass point, rigid body and multibody systems.
- describe the kinetics of a mass point and rigid body.
- differentiate and describe collision processes.
- model the dynamics of multibody systems.

## Contents

1. Kinematics
  - 1.1 Motion of a Mass Point: Trajectory, Velocity, Acceleration, etc.
  - 1.2 Motion of Rigid Bodies: Position, Orientation, Translation, and Rotation in 3D, etc.
  - 1.3 Motion of Multibody Systems: Joint Types, Configuration, Homogeneous Transformation, Forward and Backward Kinematics, Differential Kinematics, Singularities, etc.
  - 1.4 Motion Planning: Reaching Configurations in Joint Space and Cartesian Space, etc.
2. Kinetics
  - 2.1 Mass Point: Free and Guided Motion, Momentum-, Moment-, Energy-, and Work-Theorem, Collision, etc.
  - 2.2 System of Mass Points: Center of Mass, Linear Momentum, Angular Momentum, and Energy Conservation Law, etc.
  - 2.3 Rigid Bodies: Linear and Angular Momentum Theorem, Inertia Tensor, Euler Equation of Motion, etc.

3. Collisions
  - 3.1 Shock Phases: Compression, Restitution, Coefficient of Restitution, etc.
  - 3.2 Straight Collision: Approach Speeds, etc.
  - 3.3 Oblique Collision: Approach Velocities, etc.
  - 3.4 Centric Collision: Collision Normal and Center of Mass, etc.
  - 3.5 Eccentric Collision: Collision Normal and Center of Mass, etc.
4. Multibody System Dynamics
  - 4.1 Lagrange Function: Potential and Kinetic Energy, Principle of Least Action, etc.
  - 4.2 Lagrange Equations: Generalized Coordinates and Forces, etc.
  - 4.3 D'Alembert's Principle: Constraint Forces, Virtual Work, etc.
  - 4.4 Newton-Euler Equations: with Injected Forces and Constraint Forces, etc.
5. Oscillation
  - 5.1 Spring Systems: Serial, Parallel, Equivalent Stiffness, etc.
  - 5.2 Free Oscillations Linear: Mass-Spring System, Mass-Damper-Spring System, etc
  - 5.3 Free Oscillations Nonlinear: Pendulum, etc
  - 5.4 Forced Oscillations: Mass-Spring System, Mass-Damper-Spring System, Standard Excitations, etc.

### Literature

#### Compulsory Reading

#### Further Reading

- Ben-Ari, M./Mondada, F. (2017): Elements of Robotics. Springer International Publishing, Cham.
- Corke, P. (2017): Robotics, Vision and Control: Fundamental Algorithms In MATLAB. 2nd ed., Springer International Publishing, Cham.
- Mihelj, M., et al (2018): Robotics. 2nd ed., Springer International Publishing, Cham.
- Siciliano, B./Khatib, O. (Eds.) (2016): Springer Handbook of Robotics. Springer International Publishing, Cham.
- Siciliano, B., Sciavicco, L., Villani, L. Oriolo, G. (2009): Robotics Modeling Planning and Control. Springer-Verlag London

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>		
<input type="checkbox"/> Learning Sprints®	<input type="checkbox"/> Review Book	<input type="checkbox"/> Sprint
<input checked="" type="checkbox"/> Course Book	<input type="checkbox"/> Creative Lab	<input checked="" type="checkbox"/> Interactive Online Lecture
<input type="checkbox"/> Vodcast	<input type="checkbox"/> Guideline	
<input checked="" type="checkbox"/> Shortcast	<input checked="" type="checkbox"/> Live Tutorium/Course Feed	
<input checked="" type="checkbox"/> Audio	<input type="checkbox"/> Reader	
<input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Slides	

DLBROMKD01\_E

## Technical Mechanics: Elastostatics

Module Code: DLBBIWTM\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> None	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 3. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Technical Mechanics: Elastostatics)

### Contributing Courses to Module

- Technical Mechanics: Elastostatics (DLBBIWTM01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Stress and Strain on a Single Truss
- Introduction to Elasticity Theory
- Stress States and Law of Elasticity
- Bernoulli Beam Theory
- Stability and Equilibrium States
- Shear and Torsion
- Euler Buckling

**Learning Outcomes****Technical Mechanics: Elastostatics**

On successful completion, students will be able to

- determine stresses and deformations on the elastic truss.
- apply the energy principles to determine reaction and internal forces (stress resultants).
- describe stress- and strain conditions.
- discuss the stability of an equilibrium state.
- determine cross-section properties of any cross-section.
- determine beam deflections with and without the influence of normal force and temperature.
- calculate stresses and deformations in shear and torsion.
- investigate buckling in Euler bar-cases.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Design, Architecture & Construction

**Links to other Study Programs of the University**

All Bachelor Programs in the field of Civil Engineering

## Technical Mechanics: Elastostatics

Course Code: DLBBIWTM01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

### Course Description

Solid mechanics applies physical principles to engineering systems and is a fundamental discipline in engineering. This course focuses on theory of elasticity. In contrast to statics, which assumes rigid bodies, theory of elasticity deals in principle with deformable bodies. Knowledge of elasticity theory is the basis for design and deformation calculations in reinforced and prestressed concrete structures, steel structures and timber structures. After successfully completing the module, students should understand the idealizations and model concepts used in theory of elasticity and carry out their own initial calculations of stresses and deformations on beam-shaped components. Solid mechanics is an important basic subject in civil engineering. Knowledge of Solid mechanics is a prerequisite for other modules in structural engineering.

### Course Outcomes

On successful completion, students will be able to

- determine stresses and deformations on the elastic truss.
- apply the energy principles to determine reaction and internal forces (stress resultants).
- describe stress- and strain conditions.
- discuss the stability of an equilibrium state.
- determine cross-section properties of any cross-section.
- determine beam deflections with and without the influence of normal force and temperature.
- calculate stresses and deformations in shear and torsion.
- investigate buckling in Euler bar-cases.

### Contents

1. Cross-Section Values
  - 1.1 Basic Terms
  - 1.2 Moments of Area
  - 1.3 Section Modulus
  - 1.4 Principle Axes and Principle Area Moment

2. Normal Stress and Strain
  - 2.1 Basic Load Types
  - 2.2 Basic Concepts of Stress and Deformation
  - 2.3 Strain Due to Forces and Temperature
  - 2.4 Stress Concentration Effects
3. Shear Force and Torsion for Simple Cross Sections
  - 3.1 Introduction to the Subject of Shear Stress
  - 3.2 Shear Stress Due to Shear Force
  - 3.3 Shear, Angular Change and Torsional Moments
  - 3.4 Torsion in Circular and Annular Cross Sections
  - 3.5 Combined Loading from Shear Force and Torsion
4. Bending of Beams
  - 4.1 Bernoulli Beam Theory
  - 4.2 Uniaxial and Biaxial (Inclined) Bending
  - 4.3 Bending with Axial Force
  - 4.4 Influence of Temperature
5. Stress State and Law of Elasticity
  - 5.1 Plane Stress State
  - 5.2 Mohr's Stress Circle
  - 5.3 Hoop-Stress- (Barlow's-) Formula
  - 5.4 Strain States
  - 5.5 Law of Elasticity
6. Stability
  - 6.1 Basics
  - 6.2 Stability Problems
  - 6.3 Euler Buckling Cases



**Literature****Compulsory Reading****Further Reading**

- Engineering Mechanics 2 : Mechanics of Materials, Dietmar Gross, Werner Hauger, Jörg Schröder, Wolfgang A. Wall, Javier Bonet, 2nd edition. Berlin : Springer. 2018
- Engineering Mechanics : Volume 2: Stresses, Strains, Displacements, C. Hartsuijker, J.W. Welleman, Dordrecht : Springer. 2007
- Solid Mechanics, Hosford, William F., New York : Cambridge University Press. 2010

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>		
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input type="checkbox"/> Slides	<input type="checkbox"/> Sprint <input checked="" type="checkbox"/> Interactive Online Lecture





# 4. Semester

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## Introduction to Electromagnetics

Module Code: DLBENGEE1

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> DLBINGET01-01_E	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 4. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Introduction to Electromagnetics)

### Contributing Courses to Module

- Introduction to Electromagnetics (DLBENGEE01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Static Electric and Magnetic Fields
- Maxwell's Equations and Electromagnetic Waves
- Transmission Lines and Antennas

**Learning Outcomes****Introduction to Electromagnetics**

On successful completion, students will be able to

- understand and apply mathematical principles of vector algebra and calculus.
- reiterate and understand basic concepts of electromagnetic field theory.
- understand and analyze electric and magnetic fields.
- reproduce and understand the fundamentals of electrodynamics, in particular Maxwell's equations.
- understand and analyze the fundamentals of wave propagation.
- understand and use transmission line theory.
- understand and analyze the operation of waveguides.
- reproduce and understand the fundamentals of radiation fields and antennas .

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field



# Introduction to Electromagnetics

Course Code: DLBENGEE01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBINGET01-01_E

## Course Description

Electromagnetic fields and waves are fundamental topics in engineering. In addition to providing a deeper understanding of the concepts of electrical circuits and networks, they introduce into the basis for the analysis of important phenomena in microelectronics, electrical power, and other fields. Most importantly, they provide the foundation for the study of advanced topics such as wireless networks and communication systems. For these reasons, the course begins by introducing the mathematical concepts necessary for the treatment of electromagnetic principles. The fundamentals of electric and magnetic fields are presented. A detailed explanation of Maxwell's equations provides the most important fundamentals of electrodynamics, followed by an explanation of wave propagation in different materials. To further present the applied side of electromagnetics, an overview of practical systems such as transmission lines and antennas is presented.

## Course Outcomes

On successful completion, students will be able to

- understand and apply mathematical principles of vector algebra and calculus.
- reiterate and understand basic concepts of electromagnetic field theory.
- understand and analyze electric and magnetic fields.
- reproduce and understand the fundamentals of electrodynamics, in particular Maxwell's equations.
- understand and analyze the fundamentals of wave propagation.
- understand and use transmission line theory.
- understand and analyze the operation of waveguides.
- reproduce and understand the fundamentals of radiation fields and antennas .

## Contents

1. Fundamental Concepts
  - 1.1 The Electromagnetic Model
  - 1.2 Units and Constants
  - 1.3 Scalars and Vectors
  - 1.4 Vector Algebra
  - 1.5 Vector Analysis

2. Static Electric Fields
  - 2.1 Coulomb's Law
  - 2.2 Gauss's Law and Electric Potential
  - 2.3 Materials in Static Electric Field
  - 2.4 Capacitance
  - 2.5 Energy and Forces
3. Static Magnetic Fields
  - 3.1 Biot-Savart Law
  - 3.2 Ampere's Law
  - 3.3 Magnetic Flux and Magnetic Flux Density
  - 3.4 Magnetic Materials & Permeability
  - 3.5 Inductance
4. Maxwell's Equations
  - 4.1 Time Varying Fields
  - 4.2 Maxwell's Equations
  - 4.3 Potential Functions
  - 4.4 Boundry Conditions
  - 4.5 Special Forms of Maxwell's Equations
5. Electromagnetic Waves
  - 5.1 The Wave Equation and its Solution
  - 5.2 The Electromagnetic Spectrum
  - 5.3 The Poynting Theorem and Poynting Vector
  - 5.4 Plane Waves in Materials
  - 5.5 Reflection and Refraction of Plane Waves
6. Transmission Lines and Waveguides
  - 6.1 Structure and Definitions
  - 6.2 Transverse Electromagnetic Wave in Transmission Line
  - 6.3 The Smith Chart
  - 6.4 Types of Waveguides
  - 6.5 Cavity Resonators

7. Antennas
  - 7.1 Electromagnetic Radiation
  - 7.2 Electric and Magnetic Dipoles
  - 7.3 Antenna Properties and Parameters
  - 7.4 The Linear Antenna
  - 7.5 Antenna Arrays and other Types

**Literature****Compulsory Reading****Further Reading**

- Balanis, C. (2015): Antenna Theory: Analysis and Design. 4. Auflage, John Wiley & Sons, New Jersey
- Cheng, D. (2014): Field and Wave Electromagnetics. 2.Auflage, Pearson, New York.
- Ida, N. (2015): Engineering Electromagnetics. 3.Auflage, Springer, Berlin.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Fundamentals of Systems Simulation

Module Code: DLBENGFSS

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> None	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 4. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Fundamentals of Systems Simulation)

### Contributing Courses to Module

- Fundamentals of Systems Simulation (DLBENGFSS01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam or Advanced Workbook

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Computer Simulation
- Continuous-Time Systems
- Elementary Numerical Integration
- Intermediate Numerical Integration
- Discrete-Event Systems

**Learning Outcomes****Fundamentals of Systems Simulation**

On successful completion, students will be able to

- run computer simulations of continuous-time systems.
- understand the main issues related to computer simulation.
- evaluate simulation results.
- use simulations for design of engineering systems.
- understand the main ideas behind discrete-event systems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field

# Fundamentals of Systems Simulation

Course Code: DLBENGFSS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

## Course Description

Computer Simulation is a very powerful tools which allows for designing, exploring, understanding, testing as well as prototyping of ideas or solutions. Being able to set-up a good simulation should belong to the competence bag of any engineer. This course provides the basics to understand how simulation works and can be used. The first part focuses on continuous-time simulation, while the last part addresses the very basics of event-driven systems, which are ubiquitous in industry and applications.

## Course Outcomes

On successful completion, students will be able to

- run computer simulations of continuous-time systems.
- understand the main issues related to computer simulation.
- evaluate simulation results.
- use simulations for design of engineering systems.
- understand the main ideas behind discrete-event systems.

## Contents

1. Computer Simulation
  - 1.1 Introduction
  - 1.2 Continuous-Time Simulation
  - 1.3 Discrete-Event Simulation
  - 1.4 Monte-Carlo Simulation
2. Continuous-Time Systems
  - 2.1 First-Order Systems
  - 2.2 Second-Order Systems
  - 2.3 State Variables
  - 2.4 Nonlinear Systems

3. Elementary Numerical Integration
  - 3.1 Euler Integration
  - 3.2 Trapezoidal Integration
  - 3.3 Discrete-State Equations
  - 3.4 Improved and Modified Euler Integration
4. Intermediate Numerical Integration
  - 4.1 Runge-Kutta
  - 4.2 Adaptive Systems
  - 4.3 Multistep Methods
  - 4.4 Stiff Systems
  - 4.5 Discontinuities
5. Discrete-Event Systems
  - 5.1 Basics
  - 5.2 Modeling Framework
  - 5.3 Examples
  - 5.4 Application Frameworks

### Literature

#### Compulsory Reading

#### Further Reading

- Banks, J., Carson, J. S. I., Nelson, B. L., & Nicol, D. M. (2009). Discrete-Event System Simulation (5th ed.). Pearson College.
- Choi, B. K., & Kang, D. (2013). Modeling and simulation of discrete-event systems. John Wiley & Sons Inc.
- Cassandras, C. G., & Lafortune, S. (2008). Introduction to discrete event systems. Springer US.
- Klee, H., & Allen, R. (2017). Simulation of dynamic systems with MATLAB and Simulink (3rd ed.). CRC Press.
- Loper, M. L. (Ed.). (2015). Modeling and Simulation in the Systems Engineering Life Cycle. London: Springer London.



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam or Advanced Workbook

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBENGFSS01

## Introduction to Data Protection and Cyber Security

Module Code: DLBCSIDPITS

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 4. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Prof. Dr. Ralf Kneuper (Introduction to Data Protection and Cyber Security)

### Contributing Courses to Module

- Introduction to Data Protection and Cyber Security (DLBCSIDPITS01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

Study Format: myStudies  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Fundamentals of IT Security
- Data Protection
- IT Security Management
- Network and Communication Security

<p><b>Learning Outcomes</b></p> <p><b>Introduction to Data Protection and Cyber Security</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ explain the terms and concepts of IT security and know the typical procedures and techniques which exist in each area.</li> <li>▪ cite the legal regulations on data protection and explain their implementation.</li> <li>▪ discuss in-depth IT security management and suitable measures for implementation.</li> <li>▪ use their overview knowledge of activities and strategies for IT security in software and system development.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field(s) of Computer Science &amp; Software Development.</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programmes in the IT &amp; Technology field(s).</p>

## Introduction to Data Protection and Cyber Security

Course Code: DLBCSIDPITS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

In this course, the students are familiarized with important concepts from the field of IT security. Basic terms are introduced and discussed, and typical application fields, areas of IT security application, and typical procedures and techniques are introduced and described.

### Course Outcomes

On successful completion, students will be able to

- explain the terms and concepts of IT security and know the typical procedures and techniques which exist in each area.
- cite the legal regulations on data protection and explain their implementation.
- discuss in-depth IT security management and suitable measures for implementation.
- use their overview knowledge of activities and strategies for IT security in software and system development.

### Contents

1. Fundamentals of Data Protection and Cyber Security
  - 1.1 Conceptual Bases, Protection Goals
  - 1.2 Attacks and Threats
  - 1.3 Security Strategy
  - 1.4 Legal Regulations
2. Data Protection
  - 2.1 Data Protection as a Personal Right
  - 2.2 Basic Principles of Data Protection
  - 2.3 EU General Data Protection Regulation
  - 2.4 Further International Regulations on Data Protection
  - 2.5 Cross-Border Data Flow
  - 2.6 Data Protection in Everyday Life

3. Basic Functions of Cyber Security and Their Implementation
  - 3.1 Identification and Authentication
  - 3.2 Rights Management
  - 3.3 Rights Check
  - 3.4 Preservation of Evidence
4. Cyber Security Management
  - 4.1 Basic Concepts and Standards in Cyber Security Management
  - 4.2 Series of Standards ISO 2700x
5. Cyber Security Management in Everyday Life
  - 5.1 Password Management
  - 5.2 Data Backup
  - 5.3 Email Security
  - 5.4 Protection Against Viruses and Other Malware
  - 5.5 Protection Against Social Engineering Attacks
6. Network and Communication Security
  - 6.1 Firewall Technology
  - 6.2 Network Separation
  - 6.3 Security in WLAN, Mobile Networks, Bluetooth, and NFC
7. Cyber Security in the Development of Software and Systems
  - 7.1 Protection of the Development Environment
  - 7.2 Secure Development
  - 7.3 Common Criteria

### Literature

#### Compulsory Reading

#### Further Reading

- Arnold, R. (2017). Cybersecurity: A business solution. An executive perspective on managing cyber risk. Threat Sketch.
- Mattord, H., & Whitman, M. (2017). Management of information security. Cengage.
- European Parliament and Council of the European Union. (2016). EU General Data Protection Regulation (GDPR): Regulation 2016/679 of the European Parliament and of the council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). Official Journal of the European Union. Chapters 1–3

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



## Statistics: Probability and Descriptive Statistics

Module Code: DLBDSSPDS

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 4. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Dr. Stefan Stöckl (Statistics: Probability and Descriptive Statistics )

### Contributing Courses to Module

- Statistics: Probability and Descriptive Statistics (DLBDSSPDS01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

Study Format: myStudies  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Probability
- Random variables
- Joint distributions
- Expectation and variance
- Inequalities and limit theorems

**Learning Outcomes**

**Statistics: Probability and Descriptive Statistics**

On successful completion, students will be able to

- define probability, random variable, and probability distribution.
- understand the concept of Bayesian statistics.
- grasp the definition of joint and marginal distributions.
- calculate expectation values and higher moments.
- comprehend important inequality equations and limit theorems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Methods

**Links to other Study Programs of the University**

All Bachelor Programmes in the Business & Management fields

# Statistics: Probability and Descriptive Statistics

Course Code: DLBDSSPDS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Statistical description and analysis are the foundations for data-driven analysis and prediction methods. This course introduces the fundamentals, beginning with a formal definition of probabilities and introduction to the concepts underlying Bayesian statistics. Random variables and probability density distributions are then discussed, as well as the concept of joint and marginal distributions. The importance of various discrete and continuous distributions and their applications is stressed. Characterizing distributions is an important aspect of describing the behavior of probability distributions. Students are familiarized with expectation values, variance, and covariance. The concepts of algebraic and central moments and moment-generating functions complement the characterization of probability distributions. Finally, this course focuses on important inequalities and limit theorems such as the law of large numbers or the central limit theorem.

## Course Outcomes

On successful completion, students will be able to

- define probability, random variable, and probability distribution.
- understand the concept of Bayesian statistics.
- grasp the definition of joint and marginal distributions.
- calculate expectation values and higher moments.
- comprehend important inequality equations and limit theorems.

## Contents

1. Probability
  - 1.1 Definitions
  - 1.2 Independent events
  - 1.3 Conditional probability
  - 1.4 Bayesian statistics
2. Random Variables
  - 2.1 Random Variables
  - 2.2 Distribution functions and probability mass functions
  - 2.3 Important discrete probability distributions
  - 2.4 Important continuous probability distributions

3. Joint Distributions
  - 3.1 Joint distributions
  - 3.2 Marginal distributions
  - 3.3 Independent random variables
  - 3.4 Conditional distributions
4. Expectation and Variance
  - 4.1 Expectation of a random variable, conditional expectations
  - 4.2 Variance and covariance
  - 4.3 Expectations and variances of important probability distributions
  - 4.4 Algebraic and central moments
  - 4.5 Moment-generating functions
5. Inequalities and Limit Theorems
  - 5.1 Probability inequalities
  - 5.2 Inequalities for expectations
  - 5.3 The law of large numbers
  - 5.4 Central limit theorem

**Literature****Compulsory Reading****Further Reading**

- Downey, A.B. (2011). Think stats (2nd ed.). Sebastopol, CA: O'Reilly
- Kim, A. (2019). Exponential Distribution—Intuition, Derivation, and Applications. Available online.
- Wasserman, L. (2004). All of Statistics: A concise course in statistical inference. New York, NY: Springer

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Introduction to Programming with Python

Module Code: DLBDSIPWP

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 4. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Dr. Reza Shahbazfar (Introduction to Programming with Python)

### Contributing Courses to Module

- Introduction to Programming with Python (DLBDSIPWP01)

### Module Exam Type

#### Module Exam

Study Format: myStudies  
Exam, 90 Minutes

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Python as a programming language for data science
- Variables and built-in datatypes
- Statements and functions
- Error and exception handling
- Important Python data science modules

**Learning Outcomes****Introduction to Programming with Python**

On successful completion, students will be able to

- use fundamental Python syntax.
- recollect common elementary data types.
- recognize foundational programming concepts and their realization in Python.
- understand error handling and logging.
- create working programs.
- list the most important libraries and packages for data science.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field(s) of Data Science & Artificial Intelligence.

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology field(s).



# Introduction to Programming with Python

Course Code: DLBDSIPWP01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

This course provides students with a foundational understanding of the Python programming language. Following an introductory exposition to the importance of Python for data science-related programming tasks, students will be acquainted with fundamental programming concepts like variables, data types, and statements. Building on this basis, the important notion of a function is explained and errors, exception handling, and logging are explicated. The course concludes with an overview of the most widely-used library packages for data science.

## Course Outcomes

On successful completion, students will be able to

- use fundamental Python syntax.
- recollect common elementary data types.
- recognize foundational programming concepts and their realization in Python.
- understand error handling and logging.
- create working programs.
- list the most important libraries and packages for data science.

## Contents

1. Introduction
  - 1.1 Why Python?
  - 1.2 Obtaining and installing Python
  - 1.3 The Python interpreter , IPython, and Jupyter
2. Variables and Data Types
  - 2.1 Variables and value assignment
  - 2.2 Numbers
  - 2.3 Strings
  - 2.4 Collections
  - 2.5 Files

3. Statements
  - 3.1 Assignment, expressions, and print
  - 3.2 Conditional statements
  - 3.3 Loops
  - 3.4 Iterators and comprehensions
4. Functions
  - 4.1 Function declaration
  - 4.2 Scope
  - 4.3 Arguments
5. Errors and Exceptions
  - 5.1 Errors
  - 5.2 Exception handling
  - 5.3 Logs
6. Modules and Packages
  - 6.1 Usage
  - 6.2 Namespaces
  - 6.3 Documentation
  - 6.4 Popular data science packages

## Literature

### Compulsory Reading

#### Further Reading

- Barry, P. (2016). Head first Python: A brain-friendly guide. Sebastopol, CA: O'Reilly Media, Inc.
- Kapil, S. (2019). Clean Python: Elegant coding in Python. Berkeley, CA: Apress.
- Lubanovic, B. (2019). Introducing Python (2nd ed.). Sebastopol, CA: O'Reilly.
- Lutz, M. (2013). Learning Python (5th ed.). Sebastopol, CA: O'Reilly.
- Matthes, E. (2015). Python crash course: A hands-on, project-based introduction to programming. San Fransisco, CA: No Starch Press.
- Müller, A. C., & Guido, S. (2016). Introduction to machine learning with Python: A guide for data scientists. Sebastopol, CA: O'Reilly Media, Inc.
- Ramalho, L. (2015). Fluent Python: Clear, concise, and effective programming. Sebastopol, CA: O'Reilly.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Project: Simulation of Systems

Module Code: DLBENGPSS

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> DLBENGFSS01	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 4. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Project: Simulation of Systems)

### Contributing Courses to Module

- Project: Simulation of Systems (DLBENGPSS01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Written Assessment: Project Report

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

The course provides the main practical competences to set-up, run and evaluate simulations of systems.

**Learning Outcomes****Project: Simulation of Systems**

On successful completion, students will be able to

- set-up a simulation of a system (of systems).
- run a simulation and adjust simulation parameters to achieve better results.
- evaluate the output of the simulation.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field

## Project: Simulation of Systems

Course Code: DLBENGPSS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBENGFSS01

### Course Description

Simulation is a powerful tool for design, evaluating, exploring, prototyping and testing ideas and solutions. This course provides the main competences about systems simulation.

### Course Outcomes

On successful completion, students will be able to

- set-up a simulation of a system (of systems).
- run a simulation and adjust simulation parameters to achieve better results.
- evaluate the output of the simulation.

### Contents

- The course gathers the practical know-how about simulation of systems, with a particular emphasis on continuous-time simulation. The students will be able to set-up a simulation, initialize it, and evaluate/discuss its results.

### Literature

#### Compulsory Reading

#### Further Reading

- Banks, J., Carson, J. S. I., Nelson, B. L., & Nicol, D. M. (2009). Discrete-Event System Simulation (5th ed.). Pearson College.
- Choi, B. K., & Kang, D. (2013). Modeling and simulation of discrete-event systems. John Wiley & Sons Inc.
- Cassandras, C. G., & Lafortune, S. (2008). Introduction to discrete event systems. Springer US.
- Klee, H., & Allen, R. (2017). Simulation of dynamic systems with MATLAB and Simulink (3rd ed.). CRC Press.
- Loper, M. L. (Ed.). (2015). Modeling and Simulation in the Systems Engineering Life Cycle. London: Springer London.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides







# 5. Semester

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# Fundamentals of Data-Driven Engineering

Module Code: DLBENGFDDDE

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> None	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 5. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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## Module Coordinator

N.N. (Fundamentals of Data-Driven Engineering)

## Contributing Courses to Module

- Fundamentals of Data-Driven Engineering (DLBENGFDDDE01)

## Module Exam Type

### Module Exam

Study Format: Distance Learning  
Written Assessment: Case Study

### Split Exam

## Weight of Module

see curriculum

## Module Contents

- Basic Optimization
- Static Models
- Linear System Identification
- Time-Frequency Analysis
- Singular Value Decomposition
- Compressed Sensing

**Learning Outcomes****Fundamentals of Data-Driven Engineering**

On successful completion, students will be able to

- set-up an optimization problem and solve it with the aid of software tools.
- apply models and fit them to data.
- identify linear models based on data and use them for prediction.
- understand the emerging field of compressed sensing and apply it to practical scenarios.
- use Singular Value Decomposition to identify the principal components in a data-driven system.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Data Science & Artificial Intelligence

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field

# Fundamentals of Data-Driven Engineering

Course Code: DLBENGFDDDE01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

## Course Description

Data are driving the way in which we nowadays perform several activities. Data enable understanding phenomena which would be otherwise very complex. To this aim, practitioners and engineers need to develop appropriate competences and know-how about analyzing data for specific applications. This course offers an overview and provides the fundamental knowledge about how to get the most out of data for engineering applications.

## Course Outcomes

On successful completion, students will be able to

- set-up an optimization problem and solve it with the aid of software tools.
- apply models and fit them to data.
- identify linear models based on data and use them for prediction.
- understand the emerging field of compressed sensing and apply it to practical scenarios.
- use Singular Value Decomposition to identify the principal components in a data-driven system.

## Contents

1. Basic Optimization
  - 1.1 Derivative-Free Unconstrained Optimization
  - 1.2 Unconstrained Optimization with Derivative Methods
  - 1.3 Linear Programming
  - 1.4 Simplex Method
  - 1.5 Genetic Algorithms
2. Static Models
  - 2.1 Least Squares
  - 2.2 Polynomials
  - 2.3 Splines
  - 2.4 Neural Networks

3. Linear System Identification
  - 3.1 Model Structure
  - 3.2 Time-Series Models
  - 3.3 Models with Output Feedback
  - 3.4 Models without Output Feedback
  - 3.5 Excitation Signals
4. Time-Frequency Analysis
  - 4.1 The Fourier Series and Fourier Transform
  - 4.2 Windowed Fourier Transforms
  - 4.3 Wavelets
5. Singular Value Decomposition
  - 5.1 Basics
  - 5.2 Principal Component Analysis (PCA)
  - 5.3 Proper Orthogonal Modes
  - 5.4 Robust PCS
6. Compressed Sensing
  - 6.1 The L1 Norm
  - 6.2 Sparsity and Compression
  - 6.3 Signal Reconstruction
  - 6.4 Data Reconstruction

**Literature****Compulsory Reading****Further Reading**

- Bittanti, S. (2019). Model Identification and Data Analysis. Wiley.
- Kutz, J. N. (2013). Data-Driven Modeling & Scientific Computation. Oxford University Press.
- Nelles, O. (2020). Nonlinear System Identification. Nonlinear System Identification (2nd ed.). Springer International Publishing. <https://doi.org/10.1007/978-3-030-47439-3>



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Case Study
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Case Study

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBENGFDDDE01

## Seminar: The Big Data Society

Module Code: DLBENGSTBDS

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> None	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 5. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Seminar: The Big Data Society)

### Contributing Courses to Module

- Seminar: The Big Data Society (DLBENGSTBDS01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Written Assessment: Research Essay

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

The course provides an overview on how Big Data technologies and practices are changing our society and societies.

**Learning Outcomes**

**Seminar: The Big Data Society**

On successful completion, students will be able to

- understand the impact of Big Data on our societal systems.
- understand how Big Data can be used to improve society.
- understand the main issues and risks connected to the use (and misuse) of Big Data.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Data Science & Artificial Intelligence

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field

## Seminar: The Big Data Society

Course Code: DLBENGSTBDS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

### Course Description

Big Data are reconfiguring the way in which our society works, for instance in the fields of business, government relations, methods, academic, social, industry. Understanding and describing the huge impact of such a collection of novel technologies and practices is an important aspect to be considered. This course gives an overview on how big data is changing our society.

### Course Outcomes

On successful completion, students will be able to

- understand the impact of Big Data on our societal systems.
- understand how Big Data can be used to improve society.
- understand the main issues and risks connected to the use (and misuse) of Big Data.

### Contents

- The course provides an overview on how Big Data technologies and practices are changing our society and societies.

### Literature

#### Compulsory Reading

#### Further Reading

- Meier, P. (2015). Digital humanitarians : how big data is changing the face of humanitarian response. Routledge.
- Japkowicz, N., & Stefanowski, J. (Eds.). (2016). Big Data Analysis: New Algorithms for a New Society. Springer International. <https://doi.org/10.1007/978-3-319-26989-4>
- O'Neil, C. (2017). Weapons of math destruction : how big data increases inequality and threatens democracy. Penguin.
- Lushetisch, N. (2020). Big Data - A New Medium? Routledge.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Seminar
------------------------------------------	-------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Research Essay

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Electrical Machines and Energy Technology

Module Code: DLBAETEME\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 5. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Electrical Machines and Energy Technology)

### Contributing Courses to Module

- Electrical Machines and Energy Technology (DLBAETEME01\_E)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Exam, 90 Minutes

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

- Electrical Signals and Electronic Circuit Elements
- Transistor Amplifiers
- Operational Amplifiers
- Feedback and Stability
- OpAmp circuits
- Active Filters
- Applications

**Learning Outcomes****Electrical Machines and Energy Technology**

On successful completion, students will be able to

- name the basic properties of electrical machines, recall them when required and apply them to technical problems.
- describe the peculiarities of different types of direct current and alternating current machines in motor and generator operation.
- perform simple calculations for the design of electrical machines.
- explain the design and application of converters and power converters.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field



# Electrical Machines and Energy Technology

Course Code: DLBAETEME01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E

## Course Description

Knowledge of electrical drive and power generation components is part of the basic qualification of electrical engineers. This include, among other things, the ability to calculate the behavior of motors and generators in steady-state operation. These fundamentals are required in many professional fields, for example in power engineering, in drive technology or also in mechatronics or robotics. In addition, other courses build on these fundamentals, for example electrical drive engineering. Knowledge of electrical machines and power engineering is thus a tool that should be mastered to pass the education of an electrical engineer. The contents of the module therefore focus on the different types and modes of operation of electrical machines.

## Course Outcomes

On successful completion, students will be able to

- name the basic properties of electrical machines, recall them when required and apply them to technical problems.
- describe the peculiarities of different types of direct current and alternating current machines in motor and generator operation.
- perform simple calculations for the design of electrical machines.
- explain the design and application of converters and power converters.

## Contents

1. Fundamentals of Electrical Machines and Power Engineering
  - 1.1 Energy Demand and Energy Coverage
  - 1.2 Power Generation
  - 1.3 Three-Phase Networks
  - 1.4 Energy Transmission

2. Direct Current Machines
  - 2.1 Structure and Components
  - 2.2 Air-Gap Field and Torque
  - 2.3 Series Machine
  - 2.4 Shunt Machine
  - 2.5 Brushless DC Motor
3. Transformer
  - 3.1 Ideal Transformer
  - 3.2 Real Transformer
  - 3.3 Pointer Diagrams
4. Three-Phase Asynchronous Machine
  - 4.1 Structure and Components
  - 4.2 Rotary Field, Voltage Induction and Torque
  - 4.3 Characteristic Curves
  - 4.4 Motor and Generator Operation
5. Three-Phase Synchronous Machine
  - 5.1 Structure and Components
  - 5.2 Full Pole Machine
  - 5.3 Motor and Generator Operation

**Literature****Compulsory Reading****Further Reading**

- Erickson, R. W., & Maksimović, D. (2020). Fundamentals of Power Electronics. Fundamentals of Power Electronics. Springer International Publishing. <https://doi.org/10.1007/978-3-030-43881-4>
- Melkebeek, J. A. (2018). Electrical Machines and Drives. Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-319-72730-1>
- Vukosavic, S. N. (2013). Electrical Machines. Electrical Machines. Springer New York. <https://doi.org/10.1007/978-1-4614-0400-2>

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBAETEME01\_E

## Project: Control Unit Design for a Mechanical System

Module Code: DLBENGEESD1

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> DLBROCSE01_E, DLBROMD01_E , DLBROMK01_E	<b>Study Level</b> BA	<b>CP</b> 5	<b>Student Workload</b> 150 h
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<b>Semester / Term</b> 5. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Project: Control Unit Design for a Mechanical System)

### Contributing Courses to Module

- Project: Control Unit Design for a Mechanical System (DLBENGEESD01)

### Module Exam Type

#### Module Exam

Study Format: Distance Learning  
Written Assessment: Project Report

#### Split Exam

### Weight of Module

see curriculum

### Module Contents

This course focuses on the application of an embedded system as a control unit, more precisely a motion control unit or motion controller for a mechanical system. In this course, the students will follow a well-defined process to design and implement such a motion controller for a real and given mechanical system.

**Learning Outcomes****Project: Control Unit Design for a Mechanical System**

On successful completion, students will be able to

- understand the relation between an embedded system and a motion controller.
- understand and describe the process of designing a motion controller.
- name the major steps or rather phases of the introduced process.
- apply the introduced process to similar mechanical systems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field

## Project: Control Unit Design for a Mechanical System

Course Code: DLBENGEESD01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBROCSE01_E, DLBROMD01_E , DLBROMK01_E

### Course Description

An embedded system consists of hardware and software. In general, it is dedicated to a larger, all-embracing system, where it fulfills special functions, mainly in the context of information processing. In many mechanical systems, equipped with actuators and sensors, an embedded system is applied to control the motion of the mechanical system. In that case the software of the embedded system contains a control algorithm and the whole embedded system works as a motion control unit or motion controller. In this course, the students will learn how embedded systems and motion controllers are related to each other. Furthermore, they will learn about the process of designing a motion controller in general. And finally, the students will apply the process to a given real system.

### Course Outcomes

On successful completion, students will be able to

- understand the relation between an embedded system and a motion controller.
- understand and describe the process of designing a motion controller.
- name the major steps or rather phases of the introduced process.
- apply the introduced process to similar mechanical systems.

### Contents

- In this course, the students will learn how to design and implement a control algorithm for a given mechanical system by following three major steps: At first the dynamic behavior of the mechanical system will be modelled. On basis of the obtained dynamic-model the control algorithm will be derived. After that the control algorithm will be implemented in the software of an embedded system, which itself is integrated in a real mechanical system, more precisely a mechatronic system. Finally, the performance of the embedded system in its function as a motion controller for a real mechanical system will be tested and evaluated in reality.

**Literature****Compulsory Reading****Further Reading**

- Bolton, W. (2019). *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering* (7th ed.). Pearson Education, New York.
- Klee, H., & Allen, R. (2017). *Simulation of dynamic systems with MATLAB and Simulink* (3rd ed.). CRC Press, Boca Raton, Florida.
- Nise, N.S. (2019). *Control Systems Engineering* (8th ed.). John Wiley & Sons, Hoboken, New Jersey.
- Russell, K., Shen, Q., & Sodhi, R. S. (2018). *Kinematics and dynamics of mechanical systems: implementation in MATLAB and SimMechanics* (2nd ed.). CRC Press, Boca Raton, Florida.



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBENGEESD01

# Introduction to Electronics and Electronic Circuits

Module Code: DLBENGEIEEC

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> DLBINGET01-01_E	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 5. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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## Module Coordinator

N.N. (Introduction to Electronics) / N.N. (Introduction to Electronic Circuits)

## Contributing Courses to Module

- Introduction to Electronics (DLBENGEE02)
- Introduction to Electronic Circuits (DLBENGEECEMET01)

## Module Exam Type

### Module Exam

### Split Exam

#### Introduction to Electronics

- Study Format "Distance Learning": Exam, 90 Minutes

#### Introduction to Electronic Circuits

- Study Format "Distance Learning": Exam, 90 Minutes

## Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Introduction to Electronics</b></p> <ul style="list-style-type: none"> <li>▪ Fundamentals of Quantum Mechanics</li> <li>▪ Structure of Atoms and Crystals</li> <li>▪ Energy Bands and Carrier Transport</li> <li>▪ Diodes and Transistors</li> </ul> <p><b>Introduction to Electronic Circuits</b></p> <ul style="list-style-type: none"> <li>▪ Electrical Signals and Electronic Circuit Elements</li> <li>▪ Transistor Amplifiers</li> <li>▪ Operational Amplifiers</li> <li>▪ Feedback and Stability</li> <li>▪ OpAmp circuits</li> <li>▪ Active Filters</li> <li>▪ Applications</li> </ul>	
<p><b>Learning Outcomes</b></p> <p><b>Introduction to Electronics</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand the basics of quantum mechanics.</li> <li>▪ understand the properties of semiconductor atoms and crystals.</li> <li>▪ reproduce and understand the electronic properties of semiconductor materials.</li> <li>▪ understand and analyze the structure and function of semiconductor circuit elements.</li> </ul> <p><b>Introduction to Electronic Circuits</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand the operation and transistors.</li> <li>▪ analyze amplifier circuits and recognize and reproduce different structures.</li> <li>▪ understand and analyze the structure and behavior of operational amplifiers.</li> <li>▪ understand and analyze the fundamentals of feedback and stability.</li> <li>▪ understand and reproduce the structure and elements of active filters.</li> <li>▪ understand and analyze oscillators and their applications.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field of Engineering</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the IT &amp; Technology field</p>

# Introduction to Electronics

Course Code: DLBENGEE02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBINGET01-01_E

## Course Description

This course teaches the fundamentals necessary for understanding how electronic components work. These are very important for the understanding of microelectronic circuits and systems. The course introduces the relevant concepts from quantum mechanics and extends them with a discussion of semiconductor physics. This is followed by a discussion of important concepts in atomic structure, crystals, and the band model of solids. Based on this, the structure and operation of the basic building blocks of electronic circuits are described.

## Course Outcomes

On successful completion, students will be able to

- understand the basics of quantum mechanics.
- understand the properties of semiconductor atoms and crystals.
- reproduce and understand the electronic properties of semiconductor materials.
- understand and analyze the structure and function of semiconductor circuit elements.

## Contents

1. Fundamental Concepts
  - 1.1 Electronics and Semiconductors
  - 1.2 Quantum Mechanics
  - 1.3 Wave-Particle Duality
  - 1.4 Uncertainty Principle
  - 1.5 Schrödinger's Equation
2. Structure of Atoms and Crystals
  - 2.1 The Bohr Model
  - 2.2 Free Electrons and the Periodic Table
  - 2.3 Types of Atomic Bonding
  - 2.4 Crystal Structure and Miller Indices
  - 2.5 Wafer Fabrication

3. Energy Bands, Doping and Carrier Transport
  - 3.1 Band Modell of Solids
  - 3.2 Intrinsic and Extrinsic Semiconductors
  - 3.3 Drift Current
  - 3.4 Diffusion Current
  - 3.5 Generation and Recombination
4. PN Junctions and Diodes
  - 4.1 Structure and Definitions
  - 4.2 PN-Junction without External Voltage
  - 4.3 PN-Junction with External Voltage
  - 4.4 Capacitance of a PN-Junction
  - 4.5 Heterojunctions
5. Bipolar Junction Transistors
  - 5.1 Definition of the Transistor
  - 5.2 Structure and Simple Model
  - 5.3 Ebers-Moll Equations and Model
  - 5.4 Current-Voltage-Characteristics
  - 5.5 Amplification Parameters
6. Metal-Semiconductor Contacts and Field-Effect Transistors
  - 6.1 Schottky and Ohmic Contacts
  - 6.2 Types of Field Effect Transistors
  - 6.3 The MOS Capacitor
  - 6.4 The MOSFET
  - 6.5 Equations and Characteristic Curve

**Literature****Compulsory Reading****Further Reading**

- Sedra, A., Smith, K. (2015): Microelectronic Circuits. 7. edition, Oxford University Press, New York.
- Sze, S. (2007): Physics of Semiconductor Devices. 3. edition, John Wiley & Sons, New York
- Sze, S. (2002): Semiconductor Devices Physics and Technology. 2. edition, John Wiley & Sons, New York

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Introduction to Electronic Circuits

Course Code: DLBENGEECEMET01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBINGET01-01_E

### Course Description

Electronic circuits are critically important for numerous systems in engineering. Numerous applications in analog and digital data processing, process control and communication systems rely on electronic circuits to perform the required function. This course presents an overview of the large field of electronic circuits. A discussion of basic electronic building blocks is presented with focus on operation and fundamental circuits. Based upon this, the operational amplifier is introduced. Important concepts of feedback and stability are presented, in addition to widely used OpAmp configurations. Finally, active filters are introduced in addition to a discussion of important applications.

### Course Outcomes

On successful completion, students will be able to

- understand the operation and transistors.
- analyze amplifier circuits and recognize and reproduce different structures.
- understand and analyze the structure and behavior of operational amplifiers.
- understand and analyze the fundamentals of feedback and stability.
- understand and reproduce the structure and elements of active filters.
- understand and analyze oscillators and their applications.

### Contents

1. Introduction
  - 1.1 Electric Signals
  - 1.2 Frequency Spectrum of a Signal
  - 1.3 Analog and Digital Signals
  - 1.4 Amplifier
  - 1.5 Equivalent Circuit and Frequency Response



2. Electronic Circuit Elements
  - 2.1 Diodes and Rectifiers
  - 2.2 MOSFET Structure and Operation
  - 2.3 MOSFET Applications
  - 2.4 BJT Structure and Operation
  - 2.5 BJT Applications
3. Transistor Amplifiers
  - 3.1 Basic Concepts
  - 3.2 Small Signal Behavior and Models
  - 3.3 Simple Configurations
  - 3.4 Operating point adjustment
  - 3.5 Single Transistor Amplifiers
4. Operational Amplifiers
  - 4.1 The Ideal Operational Amplifier
  - 4.2 OpAmp Structure
  - 4.3 The Inverting and Non-Inverting Amplifier
  - 4.4 Non-Ideal Effects
  - 4.5 Large Signal Operation
5. Feedback and Stability
  - 5.1 Definitions and Basics
  - 5.2 Negative Feedback
  - 5.3 Feedback Analysis in Amplifier Circuits
  - 5.4 Feedback Analysis Using a Bode Diagram
  - 5.5 Stability and Frequency Compensation
6. OpAmp Circuits
  - 6.1 Amplifiers
  - 6.2 Constant Current Source and Buffer
  - 6.3 Adder and Difference Amplifiers
  - 6.4 The Integrating Amplifier and Differentiator
  - 6.5 Impedance Converters

7. Fundamentals of Active Filters
  - 7.1 Linear Two-Port Networks
  - 7.2 Second Order Filters
  - 7.3 The Reference Lowpass
  - 7.4 Frequency Transformations
  - 7.5 Higher Order Filters
  
8. Applications
  - 8.1 Discrete and Integrated Circuits
  - 8.2 Oscillators
  - 8.3 Analog Signal Processing
  - 8.4 Data Converters
  - 8.5 Communication Systems

**Literature**

**Compulsory Reading**

**Further Reading**

- Clayton, G. B. , Winder, S. (2003): Operational Amplifiers. 5. Edition, Elsevier, Amsterdam.
- Sedra, A., Smith, K. (2015): Microelectronic Circuits. 7. Edition, Oxford University Press, New York.
- Razavi, B. (2015): Design of Analog CMOS Integrated Circuits . 2. Edition, McGraw-Hill Education, New York.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBENGEECEMET01

## Mechatronic Systems and Design

Module Code: DLBENGEMSD

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
5. Semester	Minimaldauer: 1 Semester	WiSe/SoSe	English

### Module Coordinator

N.N. (Mechatronic Systems) / N.N. (Design of Mechatronic Systems)

### Contributing Courses to Module

- Mechatronic Systems (DLBROMSY01\_E)
- Design of Mechatronic Systems (DLBMECEMS01\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Mechatronic Systems

- Study Format "myStudies": Exam, 90 Minutes
- Study Format "Distance Learning": Exam, 90 Minutes

##### Design of Mechatronic Systems

- Study Format "Distance Learning": Exam or Advanced Workbook, 90 Minutes

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Mechatronic Systems</b></p> <ul style="list-style-type: none"> <li>▪ Modeling</li> <li>▪ Electrical drives</li> <li>▪ Machines and drivetrains</li> <li>▪ Actuators and sensors</li> </ul> <p><b>Design of Mechatronic Systems</b></p> <ul style="list-style-type: none"> <li>▪ Design process / development process</li> <li>▪ Function orientation</li> <li>▪ Function Modeling</li> <li>▪ Mechatronic composition</li> <li>▪ Structuring mechanisms</li> <li>▪ Software tools</li> </ul>	
<p><b>Learning Outcomes</b></p> <p><b>Mechatronic Systems</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand the basics of mathematical modeling of engineering systems.</li> <li>▪ model and simulate common mechatronic systems.</li> <li>▪ apply mechatronic systems for a given application.</li> <li>▪ understand the basics of actuators, sensors, and system integration.</li> </ul> <p><b>Design of Mechatronic Systems</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ name and explain the essential characteristics and interrelationships of systems and processes.</li> <li>▪ describe the essential phases of the classic, conventional product development process.</li> <li>▪ explain the special requirements of mechatronic systems in the context of product development or the development and design process.</li> <li>▪ explain comprehensively the "mechatronic composition" phase as an extension of the conventional development and design process and also apply it.</li> <li>▪ explain important ordering and structuring mechanisms for mastering the increasing complexity of technical systems in general and mechatronic systems in particular.</li> <li>▪ describe the main types of software tools that can be used during the development and design process of mechatronic systems.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field of IT &amp; Technology</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the engineering field</p>

# Mechatronic Systems

Course Code: DLBROMSY01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Numerous processes and products experience an increasing combination of traditional and advanced mechanics with electronics. Especially with information processing, this development leads to a so-called mechatronic system, with the purpose to improve overall performance. This course illustrates the development of mechatronics and focuses on some important aspects, such as modeling techniques (which are relevant for system simulation, design and optimization), common electric drives, machines and drivetrains, actuators and sensors.

## Course Outcomes

On successful completion, students will be able to

- understand the basics of mathematical modeling of engineering systems.
- model and simulate common mechatronic systems.
- apply mechatronic systems for a given application.
- understand the basics of actuators, sensors, and system integration.

## Contents

1. Introduction
  - 1.1 Mechatronic Systems
  - 1.2 Examples
2. Modeling
  - 2.1 Fundamental Equations
  - 2.2 Energy Balance
  - 2.3 Connection of Process Elements
  - 2.4 Dynamics of Mechanical Systems
  - 2.5 Mechanical Elements
3. Electrical Drives
  - 3.1 Electromagnets
  - 3.2 Direct Current Motors
  - 3.3 Alternating Current Motors

4. Machines and Drivetrains
4.1 Complete Machines
4.2 Characteristics and Stability of Machines
4.3 Motors and Pumps
4.4 Automobile Drivetrain
4.5 Signal Energy
4.6 Applications
5. Actuators and Sensors
5.1 Basic Structures
5.2 Electromechanical Drives
5.3 Hydraulic Actuators
5.4 Pneumatic Actuators
5.5 Unconventional Actuators

<b>Literature</b>
<b>Compulsory Reading</b>
<b>Further Reading</b>
<ul style="list-style-type: none"><li>▪ Boukas, E. K./Al-Sunni, F. M. (2012): Mechatronic systems: Analysis, design and implementation. Springer, Berlin.</li><li>▪ Davim, J. P. (2011): Mechatronics. John Wiley &amp; Sons, Hoboken, NJ.</li><li>▪ Isermann, R. (2005): Mechatronic systems: Fundamentals. Springer, London.</li><li>▪ Janschek, K./Richmond, K. (2012): Mechatronic systems design methods, models, concepts. Springer, Berlin</li></ul>



**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Design of Mechatronic Systems

Course Code: DLBMECEMS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

In the beginning this course briefly introduces the conventional development and design process for developing new products in the context of design theory. It starts with a task clarification and product planning phase. This is followed by the concept development phase, and by the product design phase. Products in the sense of mechatronic systems place special demands on this process since they differ from other product types by some special features. In mechatronic systems, the function of the system is the focus of interest and this function orientation is often not sufficiently taken into account in the in practice established design processes. In this course, these special requirements are described. Subsequently, the conventional design process is extended by the so-called "mechatronic composition" in order to meet the requirements. Mechatronic systems usually have a high degree of complexity, which is expected to increase in the future. This complexity must be dealt with adequately already in the development and design process in order to master it. To this end, suitable ordering and structuring mechanisms are presented in this course. Today, the entire development and design process of mechatronic systems is completely computer-based. Ideally, a complete digital image or model of the system already exists before the first prototype is manufactured. Based on this model, the system can be analyzed, designed and optimized in detail, especially with regard to its functionality, purely virtual in the computer. The types of software tools used in this context will also be briefly introduced at the end of this course.

## Course Outcomes

On successful completion, students will be able to

- name and explain the essential characteristics and interrelationships of systems and processes.
- describe the essential phases of the classic, conventional product development process.
- explain the special requirements of mechatronic systems in the context of product development or the development and design process.
- explain comprehensively the "mechatronic composition" phase as an extension of the conventional development and design process and also apply it.
- explain important ordering and structuring mechanisms for mastering the increasing complexity of technical systems in general and mechatronic systems in particular.
- describe the main types of software tools that can be used during the development and design process of mechatronic systems.

**Contents**

1. Basics
  - 1.1 Technical Systems
  - 1.2 Mechatronic Systems
2. Conventional Design Process
  - 2.1 Task Clarification and Product Planning
  - 2.2 Concept Development
  - 2.3 Product Design
3. Requirements of Mechatronic Systems
  - 3.1 Function Orientation
  - 3.2 Control Engineering and System Theory Requirements
4. Function-Oriented Design of Mechatronic Systems
  - 4.1 Design Guidelines and Functional Modeling
  - 4.2 Need for Adaptation of the Conventional Design Process
  - 4.3 Mechatronic Composition
5. Ordering and Structuring Mechanisms
  - 5.1 Hierarchization and Modularization
  - 5.2 Hierarchical Design of the Information Processing
6. Software Tools for Function-Oriented Design
  - 6.1 Tools for Function Modeling and Simulation
  - 6.2 Tools for Model Identification and Control Design
  - 6.3 Other Relevant Tools

**Literature****Compulsory Reading****Further Reading**

- Boukas, E.-K. & AL-Sunni, F. M. (2011). Mechatronic Systems - Analysis, Design and Implementation. Springer
- Janschek, K. (2012). Mechatronic Systems Design: Methods, Models, Concepts. Springer London. Springer.
- Just, V., Illg, I., Zeineldin, T. & Trächtler, A. (2010). Efficient Design of Complex Mechatronic Products Using the Example of the Separation-Process in an ATM. 10.1115/IMECE2010-38646, pp. 13-22.
- Pahl, G., Beitz, W., Feldhusen, J. & Grote, K.-H. (2007). Engineering Design: A Systematic Approach (3rd edition). Springer London.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam or Advanced Workbook, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
0 h	0 h	25 h	25 h	0 h	50 h

<b>Instructional Methods</b>		
<input type="checkbox"/> Learning Sprints®	<input type="checkbox"/> Review Book	<input type="checkbox"/> Sprint
<input checked="" type="checkbox"/> Course Book	<input type="checkbox"/> Creative Lab	<input checked="" type="checkbox"/> Interactive Online Lecture
<input type="checkbox"/> Vodcast	<input type="checkbox"/> Guideline	
<input checked="" type="checkbox"/> Shortcast	<input type="checkbox"/> Live Tutorium/Course Feed	
<input checked="" type="checkbox"/> Audio	<input type="checkbox"/> Reader	
<input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Slides	

## Robot Kinematics and Dynamics

Module Code: DLBWINWMKD\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> DLBROMK01_E	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 5. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Prof. Dr. Eric Guiffo Kaigom (Mechanics - Kinematics) / Prof. Dr. Eric Guiffo Kaigom (Mechanics - Dynamics)

### Contributing Courses to Module

- Mechanics - Kinematics (DLBROMK01\_E)
- Mechanics - Dynamics (DLBROMD01\_E)

### Module Exam Type

<b>Module Exam</b>	<b>Split Exam</b> <u>Mechanics - Kinematics</u> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Exam, 90 Minutes</li> <li>• Study Format "Distance Learning": Exam, 90 Minutes</li> </ul> <u>Mechanics - Dynamics</u> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Exam, 90 Minutes</li> <li>• Study Format "Distance Learning": Exam, 90 Minutes</li> </ul>
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### Weight of Module

see curriculum

**Module Contents****Mechanics - Kinematics**

- Motion of Rigid Bodies
- Direct Kinematics
- Inverse Kinematics
- Differential Kinematics

**Mechanics - Dynamics**

- Dynamics of Rigid Bodies
- Typical Joint Actuators
- Direct Dynamics
- Inverse Dynamics

**Learning Outcomes****Mechanics - Kinematics**

On successful completion, students will be able to

- understand and describe the motion of rigid bodies.
- understand and calculate the direct and inverse kinematic of typical robotic structures.
- calculate the differential kinematics of typical robotic structures .

**Mechanics - Dynamics**

On successful completion, students will be able to

- to understand the dynamics of rigid bodies and the basic physical laws.
- to model the dynamics of robots based on the Lagrange and Newton approaches.
- to establish dynamic equations for the design, optimization, analysis of robots.
- to understand how robot control based on a dynamic model can be realized.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields



## Mechanics - Kinematics

Course Code: DLBROMK01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

The word robot denotes a high variety of mechanical structures ranging from anthropomorphic industrial robots, to robots which mimic animals. This course provides the necessary preliminary background to develop, analyze, model, and simulate mechanical robotic structures of any kind from the viewpoint of the kinematics, i.e., neglecting forces and torques. The first part introduces the kinematics, i.e., a way to describe a robot as a kinematic chain of rigid bodies, which is important to represent position and orientation of the robotic end-effector in the operational space as function of each joint variable. The differential kinematics gives the relationship between joint velocities and corresponding velocity of the end-effector. The important problem of inverse kinematics, unavoidable when designing trajectories of the robot, is also discussed and methods for solutions are presented.

### Course Outcomes

On successful completion, students will be able to

- understand and describe the motion of rigid bodies.
- understand and calculate the direct and inverse kinematic of typical robotic structures.
- calculate the differential kinematics of typical robotic structures .

### Contents

1. Introduction
  - 1.1 Configuration Space
  - 1.2 Degrees of Freedom
  - 1.3 Topology
  - 1.4 Task Space and Workspace
2. Rigid Body Motions
  - 2.1 Pose of a Rigid Body
  - 2.2 Representations of Orientation
  - 2.3 Homogeneous Transformations
  - 2.4 Exponential Coordinate Representation

3. Forward Kinematics
  - 3.1 The Denavit-Hartenberg Convention
  - 3.2 Product of Exponentials
  - 3.3 The Universal Robot Description Format (URDF)
4. Inverse Kinematics
  - 4.1 Analytical Inverse Kinematics
  - 4.2 Numerical Inverse Kinematics
5. Differential Kinematics and Statics
  - 5.1 Manipulator Jacobian
  - 5.2 Kinematic Singularities
  - 5.3 Manipulability Ellipsoids
  - 5.4 Inverse Differential Kinematics
  - 5.5 Statics
6. Trajectory Planning
  - 6.1 Basic Concepts
  - 6.2 Trajectories in the Joint Space
  - 6.3 Trajectories in the Workspace

### Literature

#### Compulsory Reading

#### Further Reading

- Siciliano, B., & Khatib, O. (Eds.). (2016). Springer Handbook of Robotics. Springer International Publishing, Basel.
- Corke, P. (2017). Robotics, Vision and Control: Fundamental Algorithms In MATLAB® (2nd ed.). Springer International Publishing, Basel.
- Ben-Ari, M., & Mondada, F. (2017). Elements of Robotics. Springer International Publishing, Basel.
- Mihelj, M., Bajd, T., Ude, A., Lenarcic, J., Stanovnik, A., Munih, M., ... Šlajpah, S. (2018). Robotics: Second edition. Springer International Publishing, Basel.
- Lynch, K. M. & Park, F. C. (2017). Modern robotics: mechanics, planning, and control. Cambridge University Press, Cambridge.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Mechanics - Dynamics

Course Code: DLBROMD01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBROMK01_E

## Course Description

The kinematics of a robot allows describing the position and orientation (the pose) of the end-effector based on the joint variables. The presence of forces and torques, i.e., the dynamics of the motion, is completely neglected. The dynamics relates joint variables' velocities and accelerations to the forces and torques acting on the robot. This course introduces the dynamics of rigid bodies and how it can be described mathematically to be used in models, for instance for simulation purposes. The course then introduces two approaches to describe the dynamics of robots, namely the Euler-Lagrange approach and the Newton-Euler one. The Newton-Euler approach yields an iterative algorithm which can be implemented in an efficient way and can be used to calculate necessary torques to achieve required motion dynamics. The necessary torques are the input to various actuating mechanism which must be considered in the overall dynamics. This course shows how to consider the presence of DC motors and gears in the dynamic model. Finally, the main aspects relating dynamics and control are discussed briefly.

## Course Outcomes

On successful completion, students will be able to

- to understand the dynamics of rigid bodies and the basic physical laws.
- to model the dynamics of robots based on the Lagrange and Newton approaches.
- to establish dynamic equations for the design, optimization, analysis of robots.
- to understand how robot control based on a dynamic model can be realized.

## Contents

1. Basics
  - 1.1 Dynamics of a Rigid Body
  - 1.2 Classical Formulation
  - 1.3 Twist-Wrench Formulation
2. Lagrange Formulation
  - 2.1 Preliminaries
  - 2.2 General Formulation
  - 2.3 Properties
  - 2.4 Understanding the Dynamic Model

3. Newton-Euler Formulation
  - 3.1 Link Acceleration
  - 3.2 Recursive Algorithm
4. Forward and Inverse Dynamics
  - 4.1 Basic Concepts
  - 4.2 Forward Dynamics for Open Chains
  - 4.3 Newton-Euler Inverse Dynamics
  - 4.4 Dynamics in the Task Space
  - 4.5 Constrained Dynamics
  - 4.6 Robot Dynamics in the Universal Robot Description Framework
5. Actuation
  - 5.1 DC Motors and Gearings
  - 5.2 Friction
  - 5.3 Joint and Link Flexibility
6. Introduction to Motion Control
  - 6.1 The Control Problem
  - 6.2 Control in the Joint Space
  - 6.3 Control in the Operational Space

## Literature

### Compulsory Reading

### Further Reading

- Siciliano, B./Khatib, O. (Eds.) (2016): Springer Handbook of Robotics. Springer International Publishing, Basel.
- Corke, P. (2017): Robotics, Vision and Control: Fundamental Algorithms In MATLAB®. 2nd Edition, Springer International Publishing, Basel.
- Ben-Ari, M./Mondada, F. (2017): Elements of Robotics. Springer International Publishing, Basel.
- Mihelj, M. et al. (2018). Robotics: Second edition. Springer International Publishing, Basel.
- Lynch, K. M./Park, F. C. (2017). Modern robotics: mechanics, planning, and control. Cambridge University Press, Cambridge.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



## Supply Chain Management and Innovation

Module Code: DLBENGESCM I

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
5. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Hubert Vogl (Supply Chain Management I ) / Prof. Dr. Mirko Bendig (Entrepreneurship and Innovation)

### Contributing Courses to Module

- Supply Chain Management I (DLBDESECM01)
- Entrepreneurship and Innovation (DLBBAEI01\_E)

### Module Exam Type

Module Exam	Split Exam
	<p><u>Supply Chain Management I</u></p> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Exam, 90 Minutes</li> <li>• Study Format "Distance Learning": Exam, 90 Minutes</li> </ul> <p><u>Entrepreneurship and Innovation</u></p> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Written Assessment: Written Assignment</li> <li>• Study Format "Distance Learning": Written Assessment: Written Assignment</li> </ul>

### Weight of Module

see curriculum

**Module Contents****Supply Chain Management I**

- Historical and Terminological Aspects of the SCM Concept
- Motives for the Creation of Cross-Company Value Creation Networks
- Design Principles and Effects of Value Creation Networks
- Logistical Core Processes and SCM
- Information Technology Aspects of the SCM Concept
- Coordination and Collaboration of the Network Partners
- Industry-Specific Solutions of the SCM

**Entrepreneurship and Innovation**

- Entrepreneurship
- The Entrepreneur
- The Entrepreneurial Process
- Innovation
- Planning, Business Models and Strategy

**Learning Outcomes****Supply Chain Management I**

On successful completion, students will be able to

- explain the importance of cross-company value creation processes.
- understand common concepts for modeling cross-company value creation processes.
- understand dynamic effects in supply chains and can systematize their causes and effects.
- explain important theoretical concepts for describing the characteristics and challenges of cross-company value creation processes.
- explain the approaches and problem categories commonly used in the context of supply chain management.
- understand important reference and/or management models for the concretization of supply chain systems.
- name and detail important roles and tasks in the SCM network.
- deal with the coordination problem of SCM and describe the common solution approaches.

**Entrepreneurship and Innovation**

On successful completion, students will be able to

- understand the core principles of entrepreneurship.
- define the main characteristics of entrepreneurs as well as their motivations and their behavior.
- describe the entrepreneurial process with its different stages.
- recognize problems and negative side effects of entrepreneurship.
- define innovation and explain the innovation lifecycle.
- understand a business plan and what defines a business model.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Transportation & Logistics and Business Administration & Management

**Links to other Study Programs of the University**

All Bachelor Programmes in the Transport & Logistics and Business & Management fields

## Supply Chain Management I

Course Code: DLBDESCM01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

SCM proves to be an extremely multi-faceted construct from both a theoretical and a practical point of view. An adequate understanding of the problem dimensions and modes of action of (global) cross-company value creation networks requires a multidimensional approach. It starts by considering logistical processes, with modern process, flow, and network standards forming an important basis for SCM. On the basis of such an approach, students should gain a fundamental understanding of SCM. From the point of view of a holistic approach, it also makes sense to also examine a number of other typical problem areas in addition to the logistical challenges of this concept. This includes IT aspects of SCM (e.g., APS systems), and questions to do with the collaboration and coordination of network partners. This course also considers selected industry specific SCM solutions (ECR or VMI).

### Course Outcomes

On successful completion, students will be able to

- explain the importance of cross-company value creation processes.
- understand common concepts for modeling cross-company value creation processes.
- understand dynamic effects in supply chains and can systematize their causes and effects.
- explain important theoretical concepts for describing the characteristics and challenges of cross-company value creation processes.
- explain the approaches and problem categories commonly used in the context of supply chain management.
- understand important reference and/or management models for the concretization of supply chain systems.
- name and detail important roles and tasks in the SCM network.
- deal with the coordination problem of SCM and describe the common solution approaches.

### Contents

1. Fundamentals of the Supply Chain Concept
  - 1.1 Terminological and Conceptual Fundamentals
  - 1.2 Supply Chain Typology According to Otto
  - 1.3 Supply Chain Typology According to Bechtel/Jayaram
  - 1.4 Dynamic Aspects of Supply Chains

2. Selected Theoretical Concepts for the Supply Chain Concept
  - 2.1 New Institutional Economics
  - 2.2 Game Theory
  - 2.3 Network Approach
  - 2.4 Other Theoretical Additions
3. Supply Chain Management
  - 3.1 Basic Information on the Goals and Scope of SCM
  - 3.2 Popular Problem Areas of the SCM
  - 3.3 Supply Chain Management as an Evolutionary Step in Logistics
  - 3.4 Supply Chain Management as Cooperation Management
4. SCM Model
  - 4.1 Basic Information on the Term SCM Models
  - 4.2 SCOR Model
  - 4.3 SCM Task Model
5. SCM as a Coordination Problem
  - 5.1 Basic Information on the Concept of Coordination
  - 5.2 Coordination Concepts, Context, and Perspectives of SCM
  - 5.3 Coordination Instruments

## Literature

### Compulsory Reading

### Further Reading

- Bolstorff, P., & Rosenbaum, R. (2011). Supply chain excellence: A handbook for dramatic improvement using the SCOR model. AMACOM.
- Bowersox, J., Closs, D., & Cooper, M. B. (2020). Supply chain logistics management (5th ed.). McGraw Hill Education.
- Chopra, S., & Meindl, P. (2019). Supply chain management: Strategy, planning, and operation (7th ed., Global ed.). Pearson Education.
- Kurbel, K. E. (2013). Enterprise resource planning and supply chain management: Functions, business processes and software for manufacturing companies. Springer.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Entrepreneurship and Innovation

Course Code: DLBBAEI01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

Entrepreneurship and innovation are the basis and one of the driving forces of every economy. Entrepreneurship and innovation are of great importance in every phase of the economic development cycle. They are important drivers for competition, competitiveness and survival in globalized markets. In this module, students are familiarized with the ideas, motives and concepts of entrepreneurship. They also get an overview of the identification, evaluation and further development of innovations.

### Course Outcomes

On successful completion, students will be able to

- understand the core principles of entrepreneurship.
- define the main characteristics of entrepreneurs as well as their motivations and their behavior.
- describe the entrepreneurial process with its different stages.
- recognize problems and negative side effects of entrepreneurship.
- define innovation and explain the innovation lifecycle.
- understand a business plan and what defines a business model.

### Contents

1. Entrepreneurship
  - 1.1 Defining Entrepreneurship
  - 1.2 Benefits of Entrepreneurial Activity
  - 1.3 Types of Entrepreneurs
  - 1.4 Global Trends in Entrepreneurship
2. The Entrepreneur
  - 2.1 Defining Entrepreneur
  - 2.2 Characteristics of Entrepreneurs
  - 2.3 Entrepreneurial Motivation and Behavior



3. The Entrepreneurial Process
  - 3.1 Stages of the Entrepreneurial Process
  - 3.2 Venture Creation
  - 3.3 Creativity Management and Time Pressure
4. Innovation
  - 4.1 Defining Innovation
  - 4.2 Innovation Lifecycle
  - 4.3 Sources of Innovation
  - 4.4 Encouraging Entrepreneurship and Innovation
5. Planning, Business Models and Strategy
  - 5.1 Business Plan
  - 5.2 Designing a Business Model
  - 5.3 Developing a Business Strategy

**Literature****Compulsory Reading****Further Reading**

- Bessant, J., & Tidd, J. (2015). Innovation and entrepreneurship. Wiley.
- Parker, S. C. (2018). The economics of entrepreneurship (2nd ed.). Cambridge University Press.
- Scarborough, N., & Cornwall, J. (2018). Essentials of entrepreneurship and small business management (Global ed.). Pearson Education.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Written Assignment

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
------------------------------------------	--------------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Written Assignment

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBBAEI01\_E

# Operating Systems, Networks and Network Forensics

Module Code: DLBENGESNNF

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> <ul style="list-style-type: none"> <li>▪ none</li> <li>▪ DLBIBRVS01_E or DLBIBRVS01</li> </ul>	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 5. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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## Module Coordinator

Prof. Dr. Paul Libbrecht (Operating Systems, Computer Networks, and Distributed Systems) / Prof. Dr. Alexander Lawall (Introduction to Network Forensics)

## Contributing Courses to Module

- Operating Systems, Computer Networks, and Distributed Systems (DLBIBRVS01\_E)
- Introduction to Network Forensics (DLBCSEINF01\_E)

## Module Exam Type

### Module Exam

### Split Exam

Operating Systems, Computer Networks, and Distributed Systems

- Study Format "Distance Learning": Exam, 90 Minutes
- Study Format "myStudies": Exam, 90 Minutes

Introduction to Network Forensics

- Study Format "Distance Learning": Exam, 90 Minutes
- Study Format "myStudies": Exam, 90 Minutes

## Weight of Module

see curriculum

**Module Contents****Operating Systems, Computer Networks, and Distributed Systems**

- Operating Systems
- Computer Networks
- Distributed Systems
- Mobile Computing

**Introduction to Network Forensics**

- Network Protocols and Services
- World Wide Web
- Log Data Analysis
- Network Forensics

**Learning Outcomes****Operating Systems, Computer Networks, and Distributed Systems**

On successful completion, students will be able to

- explain the basic functions of operating systems.
- compare different operating systems.
- explain and compare the OSI reference model and the TCP/IP protocol stack.
- explain the most important IP-based protocols and services and their application.
- explain and compare different architectures for distributed systems.
- explain and compare the main mobile communication networks.
- explain basic challenges of the security on the Internet and their solutions.

**Introduction to Network Forensics**

On successful completion, students will be able to

- interact with the network at a low level.
- understand the idiosyncrasies of Internet protocols.
- understand how to read RFCs in self-study when protocols are modified, or new ones added.
- understand common attacks against these protocols.
- understand how encryption is used in the Internet, and how it can be subverted.
- deploy and use IDPS systems.
- recognize security events in a SIEM that uses the IDPS data.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Computer Science & Software Development

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields

# Operating Systems, Computer Networks, and Distributed Systems

Course Code: DLBIBRVS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Operating systems are a central component of computers and provide their basic functions. To an increasing extent, however, computers do not stand alone, but are integrated into networks within which data and functions of other computer systems can be accessed. This enables distributed systems in which data and functions are systematically assigned to different computers in order to perform jointly defined tasks. While in the past, the various computers were stationary, many mobile computers are now also in use, which leads to completely new application scenarios in both private and business contexts.

## Course Outcomes

On successful completion, students will be able to

- explain the basic functions of operating systems.
- compare different operating systems.
- explain and compare the OSI reference model and the TCP/IP protocol stack.
- explain the most important IP-based protocols and services and their application.
- explain and compare different architectures for distributed systems.
- explain and compare the main mobile communication networks.
- explain basic challenges of the security on the Internet and their solutions.

## Contents

1. Foundations of Operating Systems
  - 1.1 Basic Structure of Computer Systems
  - 1.2 File Systems
  - 1.3 Memory Management
  - 1.4 Processes and Threads
2. Common Operating Systems
  - 2.1 Basic Concepts: Windows
  - 2.2 Basic Concepts: Unix and Linux
  - 2.3 Basic Concepts: Apple Operating Systems
  - 2.4 Mobile Operating Systems

3. Computer Networks
  - 3.1 Principles of Data Transmission
  - 3.2 The OSI Reference Model
  - 3.3 Network Topologies
4. TCP/IP And Internet
  - 4.1 Historical background
  - 4.2 TCP/IP Protocol Stack
  - 4.3 Selected IP-Based Protocols and Services
  - 4.4 Online Security
5. Architectures of Distributed Systems
  - 5.1 Client-Server Systems and Distributed Applications
  - 5.2 Basic Concepts of Distributed Systems: Concurrency, Semaphores, Deadlock
  - 5.3 Communication in Distributed Systems
  - 5.4 Service Orientation: SOA, Web Services and Microservices
  - 5.5 Cloud Applications
  - 5.6 Transactions in Distributed Systems
  - 5.7 High-Performance Computing Cluster
6. Mobile Computing
  - 6.1 Basics, Techniques and Protocols for Mobile Computing
  - 6.2 Mobile Internet and its Applications
  - 6.3 Mobile Communication Networks
  - 6.4 Security And Data Protection in Mobile Systems

**Literature****Compulsory Reading****Further Reading**

- Tanenbaum, A. S., & Bos, H. (2015). Modern operating systems (4th ed.). Pearson.
- Tanenbaum A. S., & Wetherall, D. J. (2014) . Computer networks (5th ed.). Pearson.
- van Steen, M., & Tanenbaum , A. S. (2017). Distributed systems. (3rd ed.). Pearson. Available online.



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Introduction to Network Forensics

Course Code: DLBCSEINF01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBIBRVS01_E or DLBIBRVS01

## Course Description

Network forensics is the art and science of capturing, recording and analysis of network events in order to discover attacks. This requires an in-depth knowledge of the core Internet protocols, how they are used and how they can be attacked. In this course, we will look at the most commonly used network protocols in Internet-based networking. We take a practical approach and look at actual network traces to discover how protocols are layered on each other. At its core there is TCP/IP. Other protocols, like HTTP, are built on that layer. Others, like DNS are based on the alternative UDP protocol. The major services that make up the Internet will be discussed. For instance, DNS is a protocol, but also a distributed database system. The ICANN organization oversees IP addresses and they are allocated to regional organizations and distributed to Autonomous Systems. This requires routing which is handled by other protocols. Encryption is provided for confidentiality of data but often also for authentication and integrity reasons. It is implemented in a variety of forms with an equal variety of trade-offs. The forensic practitioner requires a variety of tools, ranging from simple probing tools to collection and analysis tools. These are usually packaged as Intrusion Detection and Prevention Systems as well as SIEMs for the actual analysis. However, security event data usually needs to be augmented with external data sources for accurate diagnosis, and a variety of data sources will be discussed.

## Course Outcomes

On successful completion, students will be able to

- interact with the network at a low level.
- understand the idiosyncrasies of Internet protocols.
- understand how to read RFCs in self-study when protocols are modified, or new ones added.
- understand common attacks against these protocols.
- understand how encryption is used in the Internet, and how it can be subverted.
- deploy and use IDPS systems.
- recognize security events in a SIEM that uses the IDPS data.

## Contents

1. Why network forensics?
  - 1.1 Goals of investigations
  - 1.2 Network evidence gathering
  - 1.3 Intrusion detection
  - 1.4 (D)Dos detection and mitigation
  - 1.5 Tools of the trade
2. Basic protocol layering
  - 2.1 Internet protocol hierarchy
  - 2.2 Connection and connectionless protocols
  - 2.3 Reading RFCs and related documentation
3. TCP vs UDP
  - 3.1 Connectionless UDP
  - 3.2 TCP Connection establishment
  - 3.3 Missing packets and retransmission
  - 3.4 SOCKS proxying
  - 3.5 Attacks against TCP and UDP
4. The Internet Protocol
  - 4.1 IP addresses, IPv4 and IPv6
  - 4.2 Obtaining an IPv4 and IPv6 addresses
  - 4.3 The role of ICANN
  - 4.4 IP Firewalls and IP Network Address Translation
  - 4.5 SOCKS Proxying Protocol and Attack Vector
5. Routing the link layer
  - 5.1 ARP (Address Resolution Protocol)
  - 5.2 RIP dynamic routing
  - 5.3 BGP peering
  - 5.4 Autonomous System numbers
  - 5.5 Attacks against routing

6. Domain Name System
  - 6.1 Host name hierarchy
  - 6.2 DNS as a distributed database
  - 6.3 DNSSEC
  - 6.4 SPF, DMARC and other special records
7. Common application layer protocols
  - 7.1 HTTP
  - 7.2 HTTP/2
  - 7.3 SMTP
8. Transport Layer Encryption
  - 8.1 SSH
  - 8.2 IPSEC
  - 8.3 TLS
  - 8.4 Man in the middle attacks
  - 8.5 Certificates and certificate authorities
9. Intrusion detection and prevention systems
  - 9.1 Sensor and event types
  - 9.2 Netflow monitoring
  - 9.3 Rules, false positive and false negatives
  - 9.4 SIEMs
  - 9.5 Attack prevention technologies
10. Correlation and enrichment data sources
  - 10.1 Enrichment of data
  - 10.2 DNS data sources: DNSBLs, passive DNS, DNS repositories
  - 10.3 AS numbers, IP blocks, GeoIP and Whois data
  - 10.4 Certificate Transparency
  - 10.5 Correlation methods

<b>Literature</b>
<b>Compulsory Reading</b>
<b>Further Reading</b> <ul style="list-style-type: none"><li>▪ Fall, K. R. / Stevens, W. R. (2012): TCP/IP Illustrated, Volume 1: The Protocols. 2nd edition, Addison-Wesley, Upper Saddle River, NJ.</li><li>▪ Matthews, J. (2005): Computer Networking: Internet Protocols in Action. Wiley, Hoboken, NJ.</li><li>▪ Stevens, W. R. (1996): TCP/IP Illustrated, Volume 3: TCP for Transactions, HTTP, NNTP, and the UNIX Domain Protocols. Addison-Wesley, Upper Saddle River, NJ.</li><li>▪ Wright, G.R. / Stevens, W. R. (1995): TCP/IP Illustrated, Volume 2: The Implementation. Addison-Wesley, Upper Saddle River, NJ.</li></ul>

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
------------------------------------------	--------------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



# Functional Programming with Python and Inferential Statistics

Module Code: DLBENGEFPPIS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	<ul style="list-style-type: none"> <li>▪ none</li> <li>▪ DLBDSSPDS01</li> </ul>	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
5. Semester	Minimum 1 semester	WiSe/SoSe	English

## Module Coordinator

Prof. Dr. Max Pumperla (Object oriented and functional programming in Python) / Dr. Stefan Stöckl (Statistics - Inferential Statistics)

## Contributing Courses to Module

- Object oriented and functional programming in Python (DLBDSOOFPP01)
- Statistics - Inferential Statistics (DLBDSSIS01)

## Module Exam Type

Module Exam	Split Exam
	<p><u>Object oriented and functional programming in Python</u></p> <ul style="list-style-type: none"> <li>• Study Format "Distance Learning": Portfolio</li> <li>• Study Format "myStudies": Portfolio</li> </ul> <p><u>Statistics - Inferential Statistics</u></p> <ul style="list-style-type: none"> <li>• Study Format "Distance Learning": Exam, 90 Minutes</li> <li>• Study Format "myStudies": Exam, 90 Minutes</li> </ul>

## Weight of Module

see curriculum

**Module Contents****Object oriented and functional programming in Python**

This course introduces the students to the advanced programming concepts of object orientation and functional programming and how they are realized in the Python programming language.

**Statistics - Inferential Statistics**

- Point Estimation
- Uncertainties
- Bayesian Inference & Non-Parametric Techniques
- Statistical Testing
- Statistical Decision Theory

**Learning Outcomes****Object oriented and functional programming in Python**

On successful completion, students will be able to

- explain basic notions in object-oriented programming such as functions and classes.
- understand object-oriented programming concepts and their relation to software design and engineering.
- describe advanced function concepts in Python.
- recognize important ideas from functional programming.
- recall important libraries for functional programming in Python.

**Statistics - Inferential Statistics**

On successful completion, students will be able to

- understand point estimation methods.
- apply maximum likelihood and ordinary least squares method to estimate parameters.
- comprehend the concept of statistical and systematic errors.
- employ error propagation methods.
- utilize Bayesian inference and non-parametric techniques.
- evaluate statistical tests.
- grasp the fundamentals of statistical decision theory.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Data Science & Artificial Intelligence and Methods

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology and Business & Management fields

# Object oriented and functional programming in Python

Course Code: DLBDSOOFPP01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

This course builds upon basic knowledge of Python programming (Introduction to Programming with Python, DLBDSIPWP) and is concerned with the exposition of advanced Python programming concepts. To this end, important notions of object-oriented programming like classes and objects and pertaining design principles are outlined. Starting from an in-depth discussion of advanced features of Python functions, functional programming concepts and their implementation in Python are conveyed.

## Course Outcomes

On successful completion, students will be able to

- explain basic notions in object-oriented programming such as functions and classes.
- understand object-oriented programming concepts and their relation to software design and engineering.
- describe advanced function concepts in Python.
- recognize important ideas from functional programming.
- recall important libraries for functional programming in Python.

## Contents

- This course provides students with a thorough introduction to important notions and concepts from the domain of object-oriented programming such as classes, objects, abstraction, encapsulation, inheritance, polymorphism, composition, and delegation. Additionally, the functional programming paradigm and pertaining ideas like functions as first class objects, decorators, pure functions, immutability and higher order functions are conveyed. Pursuant to the portfolio course type, the aforementioned concepts and ideas are explored by hands-on programming projects.

**Literature****Compulsory Reading****Further Reading**

- Lott, S. F. (2018): Functional Python programming: Discover the power of functional programming, generator functions, lazy evaluation, the built-in itertools library, and monads. 2nd ed., Packt Publishing, Birmingham.
- Lutz, M. (2013): Learning Python. 5th ed., O'Reilly, Sebastopol, CA.
- Phillips, D. (2018): Python 3 object-oriented programming: Build robust and maintainable software with object-oriented design patterns in Python 3.8. 3rd ed., Packt Publishing, Birmingham.
- Ramalho, L. (2015): Fluent Python: Clear, concise, and effective programming. O'Reilly, Sebastopol, CA.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Statistics - Inferential Statistics

Course Code: DLBDSSIS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBDSSPDS01

## Course Description

Statistical analysis and understanding are the foundations of data-driven methods and machine learning approaches. This course gives a thorough introduction to point estimators and discusses various techniques to estimate and optimize parameters. Special focus is given to a detailed discussion of both statistical and systematic uncertainties as well as propagation of uncertainties. Bayesian statistics is fundamental to data-driven approaches, and this course takes a close look at Bayesian techniques such as Bayesian parameter estimation and prior probability functions. Furthermore, this course gives an in-depth overview of statistical testing and decision theory, focusing on aspects such as A/B testing, hypothesis testing, p-values, and multiple testing which are fundamental to statistical analysis approaches in a broad range of practical applications.

## Course Outcomes

On successful completion, students will be able to

- understand point estimation methods.
- apply maximum likelihood and ordinary least squares method to estimate parameters.
- comprehend the concept of statistical and systematic errors.
- employ error propagation methods.
- utilize Bayesian inference and non-parametric techniques.
- evaluate statistical tests.
- grasp the fundamentals of statistical decision theory.

## Contents

1. Point Estimation
  - 1.1 Method of moments
  - 1.2 Sufficient statistics
  - 1.3 Maximum likelihood
  - 1.4 Ordinary least squares
  - 1.5 Resampling techniques
2. Uncertainties
  - 2.1 Statistical and systematic uncertainties
  - 2.2 Propagation of uncertainties

3.	Bayesian Inference & Non-parametric Techniques
3.1	Bayesian parameter estimation
3.2	Prior probability functions
3.3	Parzen windows
3.4	K-nearest-neighbours
4.	Statistical Testing
4.1	A/B testing
4.2	Hypothesis tests & test statistics
4.3	P-values & confidence intervals
4.4	Multiple testing
5.	Statistical Decision Theory
5.1	The risk function
5.2	Maximum likelihood, Minimax, and Bayes
5.3	Admissibility and Stein's paradox

<b>Literature</b>
<b>Compulsory Reading</b>
<b>Further Reading</b>
<ul style="list-style-type: none"><li>▪ Wasserman, L. (2004). All of statistics: A concise course in statistical inference. Springer.</li><li>▪ Downey, A. B. (2014). Think stats (2nd ed.). O'Reilly.</li><li>▪ Downey, A.B. (2013). Think bayes. O'Reilly.</li></ul>



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides





# 6. Semester

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## Electro Mobility

Module Code: DLBAETWEM\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01, DLBAETESF01 or DLBENGEEEE01	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Electrical Drive Technology) / N.N. (Battery Technology)

### Contributing Courses to Module

- Electrical Drive Technology (DLBAETWEM01\_E)
- Battery Technology (DLBAETWEM02\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Electrical Drive Technology

- Study Format "Distance Learning": Exam, 90 Minutes

##### Battery Technology

- Study Format "Distance Learning": Exam, 90 Minutes

### Weight of Module

see curriculum

**Module Contents****Electrical Drive Technology**

- Stationary Behavior of Electric Drives
- Thermal Management in Electric Drives
- Dynamic Behavior of Electric Drives
- Control of Electrical Machines: Speed Control
- Protection of Electric Drives
- Electric Drive Solutions in Automotive Engineering

**Battery Technology**

- Introduction
- Capacitors
- Accumulators
- Lithium Ion Batteries
- Battery Production
- Raw Materials and Recycling

**Learning Outcomes****Electrical Drive Technology**

On successful completion, students will be able to

- know, model, and explain basic properties of electric drives in steady-state and transient operation.
- explain the special features in thermal management and speed control of electrical drives.
- select the appropriate drive form for a given problem and perform its design.
- discuss the special features of various (partially) electric drive systems in vehicles.

**Battery Technology**

On successful completion, students will be able to

- understand technology and areas of application of energy storage systems for the energy transition.
- select and size energy storage systems.
- understand the functioning of the lithium-ion technology.
- explain specifics of battery production and recycling.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field



# Electrical Drive Technology

Course Code: DLBAETWEM01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01, DLBAETESF01 or DLBENGEEE01

## Course Description

Due to current technical and political developments, electric drives - whether in stationary machines, passenger cars or e-bikes - are becoming increasingly important. Electric drives can be found in a variety of forms, designs, and performance classes. Expertise in the specifics of electric drives is one of the key qualifications of electrical engineers. The contents of the module therefore focus on the fundamentals of different types and modes of operation of electric drives.

## Course Outcomes

On successful completion, students will be able to

- know, model, and explain basic properties of electric drives in steady-state and transient operation.
- explain the special features in thermal management and speed control of electrical drives.
- select the appropriate drive form for a given problem and perform its design.
- discuss the special features of various (partially) electric drive systems in vehicles.

## Contents

1. Stationary Behavior of Electric Drives
  - 1.1 Load Characteristics and Load Cases
  - 1.2 DC Machine
  - 1.3 Asynchronous Machines
  - 1.4 Synchronous Machines
  - 1.5 Gearbox
2. Thermal Management in Electric Drives
  - 2.1 Limit Temperatures and Insulation Classes
  - 2.2 Heat Dissipation, Heat Transfer, Heat Conduction
  - 2.3 Heat Sources
  - 2.4 Cooling Systems

3. Dynamic Behavior of Electric Drives
  - 3.1 Skin Effect
  - 3.2 Mechanical and Electromechanical Time Constants
  - 3.3 Conversion of Mechanical Quantities into Electrical Quantities
  - 3.4 Specific Dynamic Behaviors of DC Machines
  - 3.5 Specific Dynamic Behaviors of AC Machines
4. Control of Electrical Machines and Speed Control and Regulation
  - 4.1 DC Machine
  - 4.2 Asynchronous Machines
  - 4.3 Synchronous Machines
5. Protection of Electric Drives
  - 5.1 Overload
  - 5.2 Disturbances Due to the Supply
  - 5.3 Interference due to the Environment
6. Electric Drive Solutions in Automotive Engineering
  - 6.1 Hybrid Technology
  - 6.2 Fuel Cells
  - 6.3 Battery Electric Vehicles

**Literature****Compulsory Reading****Further Reading**

- Melkebeek, J. A. (2018). Electrical Machines and Drives. Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-319-72730-1>
- Pyrhonen, J./Jokinen, T./Hrabovcova, V. (2013): Design of rotating electrical machines. 2nd edition, John Wiley & Sons, Hoboken.
- Vukosavic, S. N. (2013). Electrical Machines. Electrical Machines. Springer New York. <https://doi.org/10.1007/978-1-4614-0400-2>

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
------------------------------------------	--------------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Battery Technology

Course Code: DLBAETWEM02\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01, DLBAETESF01 or DLBENGEEE01

### Course Description

Through progress in science and technology, but also through political will, battery electric storage systems for stationary and moving applications have become an alternative to conventional methods of energy provision and storage. Battery systems are finding use in new application fields such as passenger cars, e-bikes, or e-scooters, in addition to their use in classic consumer electronic devices. Expertise in the specifics of battery systems is one of the in-depth qualifications of electrical engineers. The contents of the module therefore focus on the fundamentals of different types of electrical energy storage as well as on accumulators and battery systems.

### Course Outcomes

On successful completion, students will be able to

- understand technology and areas of application of energy storage systems for the energy transition.
- select and size energy storage systems.
- understand the functioning of the lithium-ion technology.
- explain specifics of battery production and recycling.

### Contents

1. Introduction
  - 1.1 Overview of (Electrical) Energy Storage Systems
  - 1.2 Use Cases and Special Features
2. Capacitors
  - 2.1 Standard Capacitors
  - 2.2 Double Layer Capacitors
  - 2.3 Hybrid Capacitors

3. Accumulators
  - 3.1 Chemical Energy
  - 3.2 Redox Systems
  - 3.3 Galvanic Cells
  - 3.4 Lead-Acid Batteries
4. Lithium-Ion Batteries
  - 4.1 Cathode and Anode Materials
  - 4.2 Electrolytes and Separators
  - 4.3 Sensors
  - 4.4 Modeling
5. Battery Production
  - 5.1 Manufacturing Processes for Lithium-Ion Cells
  - 5.2 Cell Production
  - 5.3 Test Method
  - 5.4 Impedance Spectroscopy
6. Raw Materials and Recycling
  - 6.1 Raw Materials for Batteries
  - 6.2 Recycling of Batteries and Accumulators
7. Battery Management Systems
  - 7.1 Motivation for Battery Management
  - 7.2 Functionality of a Battery Management System
  - 7.3 Type-Specific Features

### Literature

### Compulsory Reading

### Further Reading

- Bansal, R. C., Agarwal, A., & Jadoun, V. K. (Eds.). (2022). *Advances in Energy Technology*. Singapore: Springer Singapore. <https://doi.org/10.1007/978-981-16-1476-7>
- Petrovic, S. (2021). *Battery Technology Crash Course*. Battery Technology Crash Course. Springer International Publishing. <https://doi.org/10.1007/978-3-030-57269-3>
- Thaler, A., & Watzenig, D. (Eds.). (2014). *Automotive Battery Technology*. Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-319-02523-0>

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Digital and Information Technology and Programming with C/C++

Module Code: DLBENGEDITPCC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Marian Benner-Wickner (Digital and Information Technology) / Prof. Dr. Emanuele Grasso (Programming with C/C++)

### Contributing Courses to Module

- Digital and Information Technology (DLBAETDIT01\_E)
- Programming with C/C++ (DLBROEPRS01\_E)

### Module Exam Type

Module Exam	Split Exam
	<p><u>Digital and Information Technology</u></p> <ul style="list-style-type: none"> <li>• Study Format "Distance Learning": Exam, 90 Minutes</li> </ul> <p><u>Programming with C/C++</u></p> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Portfolio</li> <li>• Study Format "Distance Learning": Portfolio</li> </ul>

### Weight of Module

see curriculum

**Module Contents****Digital and Information Technology**

- Mathematical foundations of digital logic
- Representation, synthesis and analysis of Boolean functions
- Combinational logic
- Sequential logic
- Arithmetic circuits
- Introduction to programmable logic

**Programming with C/C++**

- C and C++ for programming of applications and robots

**Learning Outcomes****Digital and Information Technology**

On successful completion, students will be able to

- understand and apply the mathematical principles of digital logic.
- understand the different ways in which combinational logic and sequential logic work.
- analyze and evaluate digital arithmetic circuits.
- understand the characteristics of programmable logic devices and develop simple arithmetic circuits on them.

**Programming with C/C++**

On successful completion, students will be able to

- know the main characteristics of C and C++ programming languages.
- apply C and C++ for programming of applications.
- apply C and C++ for programming of robotic systems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Engineering and Computer Science & Software Development

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology field



# Digital and Information Technology

Course Code: DLBAETDIT01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Digital and information technology is one of the basic subjects in electrical engineering and provides interdisciplinary basic knowledge for advanced courses. These basics are required in many courses and modules, including the realization of transistor circuits or the design of hardware-related embedded systems. Due to advances in technology, digital systems are becoming increasingly important and often replace traditional analog systems. Digital and information technology is thus a tool for the electrical engineer that should be mastered in order to gain access to more advanced know-how. This module therefore focuses not only on the theoretical fundamentals of digital and information technology (mathematical principles, combinational logic and sequential logic) but also on the practical realization of digital systems such as arithmetic circuits in programmable logic devices.

## Course Outcomes

On successful completion, students will be able to

- understand and apply the mathematical principles of digital logic.
- understand the different ways in which combinational logic and sequential logic work.
- analyze and evaluate digital arithmetic circuits.
- understand the characteristics of programmable logic devices and develop simple arithmetic circuits on them.

## Contents

1. Mathematical Foundations of Digital Logic
  - 1.1 Boolean Functions and Algebra
  - 1.2 Number Systems (Dual, Octal, Decimal, Hexadecimal) and their Application
  - 1.3 Basic Arithmetic Operations in Number Systems (Addition, Subtraction, Multiplication, Division)
  - 1.4 Coding Methods (BCD, Gray, ASCII Code)
  - 1.5 Introduction to Modulation Techniques
2. Representation, Synthesis and Analysis of Boolean Functions
  - 2.1 Disjunctive and Conjunctive Normal Form
  - 2.2 Karnaugh-Veitch Map
  - 2.3 Quine-McCluskey Algorithm

3. Combinational Logic
  - 3.1 Logic Gate
  - 3.2 Connection of Logic Gaes
  - 3.3 Substitution by NOR / NAND Gates
4. Sequential Logic
  - 4.1 Latches and Flipflops
  - 4.2 Counter and Frequency Divider
  - 4.3 Shift Register and Memory
5. State Machines
  - 5.1 Foundations
  - 5.2 Models for State Machines
  - 5.3 Representation of State Machines
  - 5.4 Event-driven / Clock-driven State Machines
  - 5.5 Synchronization of Parallel State Machines
6. Arithmetic Circuits
  - 6.1 Adders
  - 6.2 Subtractor Circuits
  - 6.3 Multiplication Circuits
7. Introduction to Programmable Logic
  - 7.1 Programmable Cell Logic and Programmable Logic Array
  - 7.2 Complex Programmable Logic Devices (CPLD)
  - 7.3 FPGAs
  - 7.4 Introduction to VHDL

**Literature****Compulsory Reading****Further Reading**

- Mano, M./Ciletti, M. (2013): Digital Design. With an Introduction to the Verilog HDL. 5th edition, Pearson, London.
- Holdsworth, B./Woods, C. (2002): Digital Logic Design. 4th edition, Newnes, London.
- Gazi, O (2019): A Tutorial Introduction to VHDL Programming. 1st edition, Springer, Singapore.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Programming with C/C++

Course Code: DLBROEPRS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

C and C++ belong to the class of programming languages which have been adopted in a broad field of applications, ranging from embedded systems (where they are dominant) to fast and reliable user interfaces and industrial applications. In fact, C++ is one of the most popular legacy programming languages for robotics, and a combination of C++ and robotics hardware is used in many leading industries. Knowledge on how to design in and write C/C++ code is an imperative capability for the practicing roboticist, especially in the industrial arena.

### Course Outcomes

On successful completion, students will be able to

- know the main characteristics of C and C++ programming languages.
- apply C and C++ for programming of applications.
- apply C and C++ for programming of robotic systems.

### Contents

- This course introduces the main aspects of C and C++ programming languages, such as data types, variables, arithmetic expressions, flow control, functions, classes, arrays, and pointers. The programming skills will then be applied to design parts of robotic systems based on popular hardware.

### Literature

#### Compulsory Reading

#### Further Reading

- Kernighan, B. W. & Ritchie, D. M. (2000). The C Programming Language, Second Edition. Pearson Education.
- Lippman, S. B., Lajoie, J., Moo, B. (2012). C++ Primer, Fifth Edition. Addison Wesley.
- Margolis, M. (2011). Arduino Cookbook. O'Reilly Media.
- Dogan, I. (2021). Nucleo Boards Programming with the STM32CubeIDE. Elektor.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
120 h	0 h	30 h	0 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

## Energy Technology

Module Code: DLBAETWET\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> <ul style="list-style-type: none"> <li>▪ Either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E</li> <li>▪ Either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01_E</li> </ul>	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimaldauer: 1 Semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (High Voltage Technology) / N.N. (Energy Industry)

### Contributing Courses to Module

- High Voltage Technology (DLBAETWET01\_E)
- Energy Industry (DLBAETWET02\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### High Voltage Technology

- Study Format "Distance Learning": Exam, 90 Minutes

##### Energy Industry

- Study Format "Distance Learning": Exam, 90 Minutes

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>High Voltage Technology</b></p> <ul style="list-style-type: none"> <li>▪ Fundamentals of high-voltage engineering and electric strength</li> <li>▪ Properties of dielectrics and insulating materials</li> <li>▪ High voltage generation, quality assurance and applications</li> </ul> <p><b>Energy Industry</b></p> <ul style="list-style-type: none"> <li>▪ Fundamentals of the energy industry</li> <li>▪ Nuclear energy and fossil fuels</li> <li>▪ Electricity markets</li> <li>▪ Energy and environment</li> </ul>	
<p><b>Learning Outcomes</b></p> <p><b>High Voltage Technology</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand and apply the fundamentals of high voltage engineering.</li> <li>▪ understand and reproduce the meaning of electric strength.</li> <li>▪ understand and reproduce the properties of dielectrics and insulating materials.</li> <li>▪ understand and apply the basics of high voltage generation and quality assurance fundamentals in high voltage engineering</li> </ul> <p><b>Energy Industry</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand and reflect the fundamentals of the energy industry.</li> <li>▪ understand and reflect technical as well as economic constraints of nuclear energy and fossil fuels.</li> <li>▪ understand and analyze the fundamentals of electricity markets and grid fees.</li> <li>▪ understand and analyze the relationship between energy generation production, environmental protection and climate change.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>All Bachelor Programs in IT &amp; Engineering</p>	<p><b>Links to other Study Programs of the University</b></p> <p>Builds on modules from the engineering field</p>



# High Voltage Technology

Course Code: DLBAETWET01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	Either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01_E

## Course Description

High voltage engineering is an important area of power engineering. In particular, knowledge of electric strength plays a central role in the design of insulation systems, especially in the specification of electrical safety. First, electric fields are introduced, with a focus on high electric field strengths and voltages. The properties of dielectrics and insulation materials are presented in detail. Practical aspects such as generation and measurement of high voltages up to diagnostic techniques are also discussed.

## Course Outcomes

On successful completion, students will be able to

- understand and apply the fundamentals of high voltage engineering.
- understand and reproduce the meaning of electric strength.
- understand and reproduce the properties of dielectrics and insulating materials.
- understand and apply the basics of high voltage generation and quality assurance fundamentals in high voltage engineering

## Contents

1. Introduction
  - 1.1 The Function of High Voltage Engineering
  - 1.2 Applications and perspectives of High Voltage Engineering
2. Electrical Stresses
  - 2.1 Electric Fields and Energy
  - 2.2 Electrical Stresses in High Voltage Engineering
  - 2.3 Homogeneous and Inhomogeneous Dielectrics
  - 2.4 Numerical Field Calculation Methods
  - 2.5 Travelling Waves

3. Electric Strength
  - 3.1 Introduction to Statistics
  - 3.2 Gas Discharges
  - 3.3 Discharges in Liquids
  - 3.4 Discharges in Solids
  - 3.5 Partial Discharges and Vacuum Breakdown
4. Properties of Dielectrics
  - 4.1 Polarization
  - 4.2 Permittivity
  - 4.3 Conductivity
  - 4.4 Description of Dielectric Material Properties
  - 4.5 Description of Geometrical Properties
5. Insulating Materials
  - 5.1 Gases
  - 5.2 Liquids
  - 5.3 Inorganic Solids
  - 5.4 High Polymer Plastics
  - 5.5 Fiber Materials
6. Generation of High Voltages
  - 6.1 High AC Voltages
  - 6.2 High DC Voltages
  - 6.3 Impulse Voltages
7. Testing, Measurements, Diagnosis and Monitoring
  - 7.1 Quality Assurance
  - 7.2 High Voltage Measurements
  - 7.3 Dielectric Measurements
  - 7.4 Dielectric Diagnosis
  - 7.5 Online Monitoring

8. Applications
  - 8.1 Insulation Systems for AC Voltages
  - 8.2 Insulation Systems for DC Voltages
  - 8.3 Insulation Systems for Impulse Voltages
  - 8.4 Lightning Protection
  - 8.5 More Applications

**Literature****Compulsory Reading****Further Reading**

- Hugh, M. Ryan. (2013): High-Voltage Engineering and Testing, 3rd edition. The Institution of Engineering and Technology, London
- Küchler, A. (2018): High Voltage Engineering. Springer Vieweg, Berlin.
- Schon, K. (2019): High voltage measurement techniques: fundamentals, measuring instruments, and measuring methods. Springer International Publishing, Basel

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>		
<input type="checkbox"/> Learning Sprints®	<input type="checkbox"/> Review Book	<input type="checkbox"/> Sprint
<input checked="" type="checkbox"/> Course Book	<input type="checkbox"/> Creative Lab	<input checked="" type="checkbox"/> Interactive Online Lecture
<input type="checkbox"/> Vodcast	<input type="checkbox"/> Guideline	
<input checked="" type="checkbox"/> Shortcast	<input type="checkbox"/> Live Tutorium/Course Feed	
<input checked="" type="checkbox"/> Audio	<input type="checkbox"/> Reader	
<input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Slides	

# Energy Industry

Course Code: DLBAETWET02\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	Either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E

## Course Description

Energy is the backbone or rather the lifeblood of modern society. However, energy generation and supply are not only a technical issue, but also an extremely important economic one. Energy is by no means infinite; rather, it is a resource that is becoming scarce. Therefore, it must be managed and its generation, distribution, and prices must be regulated. This course teaches the basics of energy management and establishes the aforementioned link between technical and economic aspects. After discussing nuclear energy, fossil fuels, and electricity markets, the critical issues of energy generation related to climate change are also discussed.

## Course Outcomes

On successful completion, students will be able to

- understand and reflect the fundamentals of the energy industry.
- understand and reflect technical as well as economic constraints of nuclear energy and fossil fuels.
- understand and analyze the fundamentals of electricity markets and grid fees.
- understand and analyze the relationship between energy generation production, environmental protection and climate change.

## Contents

1. Introduction
  - 1.1 Energy Economics and Energy Demand
  - 1.2 Energy Economics Calculations
  - 1.3 Energy Markets
  - 1.4 Goals and Tasks of Energy Policy
2. Fundamentals of the Energy Industry
  - 2.1 Main theorems of thermodynamics and Definitions
  - 2.2 Primary and Secondary Energy Sources
  - 2.3 The Energy Balance
  - 2.4 Energy Markets
  - 2.5 Resource Economics

3. Nuclear Energy
  - 3.1 The foundations of Nuclear Technology
  - 3.2 Nuclear Power Plants
  - 3.3 Nuclear Power Market
  - 3.4 Nuclear Power in Germany, Nuclear Phase-Out and Concepts for Nuclear Fusion
4. Fossil Fuels
  - 4.1 Coal
  - 4.2 Crude Oil Market
  - 4.3 Natural Gas Economy
  - 4.4 Transport and Logistics
  - 4.5 Resources and Reserves
5. Electricity Markets
  - 5.1 Features of Electricity Markets
  - 5.2 Economics of Electrical Grids
  - 5.3 Regulation of Grid Fees
  - 5.4 Electric Power Grids in Germany and the EU
  - 5.5 Unbundling
6. Energy and Environment
  - 6.1 The Greenhouse Gas Problem and Global Warming
  - 6.2 Emissions and Possible Consequences of Climate Change
  - 6.3 Climate Policy and Climate Protection Agreement
  - 6.4 Emissions Trading

**Literature****Compulsory Reading****Further Reading**

- Glachant, J.M., Joskow P, Politt, M. (2021): Handbook on Electricity Markets. Edward Elgar Publishing, Cheltenham, UK.
- Zweifel, P., Praktiknjo, A., Erdmann, G. (2017): Energy Economics: Theory and Application. Springer, Berlin.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>		
<input type="checkbox"/> Learning Sprints®	<input type="checkbox"/> Review Book	<input type="checkbox"/> Sprint
<input checked="" type="checkbox"/> Course Book	<input type="checkbox"/> Creative Lab	<input checked="" type="checkbox"/> Interactive Online Lecture
<input type="checkbox"/> Vodcast	<input type="checkbox"/> Guideline	
<input checked="" type="checkbox"/> Shortcast	<input type="checkbox"/> Live Tutorium/Course Feed	
<input checked="" type="checkbox"/> Audio	<input type="checkbox"/> Reader	
<input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Slides	

DLBAETWET02\_E



## Electrical Drive Technology and Fluid Mechanics

Module Code: DLBENGEEDTFM

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> <ul style="list-style-type: none"> <li>▪ either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01, DLBAETESF01 or DLBENGE001</li> <li>▪ None</li> </ul>	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Electrical Drive Technology) / N.N. (Fluid Mechanics)

### Contributing Courses to Module

- Electrical Drive Technology (DLBAETWEM01\_E)
- Fluid Mechanics (DLBMABSM01\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Electrical Drive Technology

- Study Format "Distance Learning": Exam, 90 Minutes

##### Fluid Mechanics

- Study Format "Distance Learning": Exam, 90 Minutes

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Electrical Drive Technology</b></p> <ul style="list-style-type: none"> <li>▪ Stationary Behavior of Electric Drives</li> <li>▪ Thermal Management in Electric Drives</li> <li>▪ Dynamic Behavior of Electric Drives</li> <li>▪ Control of Electrical Machines: Speed Control</li> <li>▪ Protection of Electric Drives</li> <li>▪ Electric Drive Solutions in Automotive Engineering</li> </ul> <p><b>Fluid Mechanics</b></p> <ul style="list-style-type: none"> <li>▪ Dimensional analysis</li> <li>▪ Hydrostatics</li> <li>▪ Hydrodynamics</li> <li>▪ Conservation of Mass, Momentum, Energy</li> <li>▪ Navier-Stokes Equations</li> <li>▪ Compressible Flows</li> <li>▪ Incompressible Fluids</li> <li>▪ Gas Dynamics</li> </ul>	
<p><b>Learning Outcomes</b></p> <p><b>Electrical Drive Technology</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ know, model, and explain basic properties of electric drives in steady-state and transient operation.</li> <li>▪ explain the special features in thermal management and speed control of electrical drives.</li> <li>▪ select the appropriate drive form for a given problem and perform its design.</li> <li>▪ discuss the special features of various (partially) electric drive systems in vehicles.</li> </ul> <p><b>Fluid Mechanics</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ name the quantities relevant in fluid mechanics.</li> <li>▪ mathematically describe the fundamentals of fluid mechanics of incompressible and compressible fluids.</li> <li>▪ describe practical questions through the initial equations of mass, energy, and impulse.</li> <li>▪ understand the importance of numerics in fluid mechanics.</li> <li>▪ distinguish laminar and turbulent flows.</li> <li>▪ explain the basics of gas dynamics.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field of Engineering</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the IT &amp; Technology field</p>

# Electrical Drive Technology

Course Code: DLBAETWEM01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01, DLBAETESF01 or DLBENGEEE01

## Course Description

Due to current technical and political developments, electric drives - whether in stationary machines, passenger cars or e-bikes - are becoming increasingly important. Electric drives can be found in a variety of forms, designs, and performance classes. Expertise in the specifics of electric drives is one of the key qualifications of electrical engineers. The contents of the module therefore focus on the fundamentals of different types and modes of operation of electric drives.

## Course Outcomes

On successful completion, students will be able to

- know, model, and explain basic properties of electric drives in steady-state and transient operation.
- explain the special features in thermal management and speed control of electrical drives.
- select the appropriate drive form for a given problem and perform its design.
- discuss the special features of various (partially) electric drive systems in vehicles.

## Contents

1. Stationary Behavior of Electric Drives
  - 1.1 Load Characteristics and Load Cases
  - 1.2 DC Machine
  - 1.3 Asynchronous Machines
  - 1.4 Synchronous Machines
  - 1.5 Gearbox
2. Thermal Management in Electric Drives
  - 2.1 Limit Temperatures and Insulation Classes
  - 2.2 Heat Dissipation, Heat Transfer, Heat Conduction
  - 2.3 Heat Sources
  - 2.4 Cooling Systems

3. Dynamic Behavior of Electric Drives
  - 3.1 Skin Effect
  - 3.2 Mechanical and Electromechanical Time Constants
  - 3.3 Conversion of Mechanical Quantities into Electrical Quantities
  - 3.4 Specific Dynamic Behaviors of DC Machines
  - 3.5 Specific Dynamic Behaviors of AC Machines
4. Control of Electrical Machines and Speed Control and Regulation
  - 4.1 DC Machine
  - 4.2 Asynchronous Machines
  - 4.3 Synchronous Machines
5. Protection of Electric Drives
  - 5.1 Overload
  - 5.2 Disturbances Due to the Supply
  - 5.3 Interference due to the Environment
6. Electric Drive Solutions in Automotive Engineering
  - 6.1 Hybrid Technology
  - 6.2 Fuel Cells
  - 6.3 Battery Electric Vehicles

**Literature****Compulsory Reading****Further Reading**

- Melkebeek, J. A. (2018). Electrical Machines and Drives. Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-319-72730-1>
- Pyrhonen, J./Jokinen, T./Hrabovcova, V. (2013): Design of rotating electrical machines. 2nd edition, John Wiley & Sons, Hoboken.
- Vukosavic, S. N. (2013). Electrical Machines. Electrical Machines. Springer New York. <https://doi.org/10.1007/978-1-4614-0400-2>

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Fluid Mechanics

Course Code: DLBMABSM01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	None

### Course Description

The course teaches the fundamentals of fluid mechanics. A distinction is made between hydrostatics and hydrodynamics as well as between compressible and incompressible fluids. The basic equations of conservation of mass, conservation of momentum, and conservation of energy are introduced in general terms so that students can simplify them to the specific application. Students learn the added value and procedure of dimensional analysis and apply it to the basic equations of fluid mechanics. In addition, the course provides an outlook on more advanced content of fluid mechanics with numerics.

### Course Outcomes

On successful completion, students will be able to

- name the quantities relevant in fluid mechanics.
- mathematically describe the fundamentals of fluid mechanics of incompressible and compressible fluids.
- describe practical questions through the initial equations of mass, energy, and impulse.
- understand the importance of numerics in fluid mechanics.
- distinguish laminar and turbulent flows.
- explain the basics of gas dynamics.

### Contents

1. Basics
  - 1.1 Subject of Fluid Mechanics
  - 1.2 Fluid
  - 1.3 Characterization of Flows
  - 1.4 Dimensional Analysis
2. Hydrostatics
  - 2.1 Hydrostatic Pressure Distribution
  - 2.2 Forces on Container Walls
  - 2.3 Translational Movement
  - 2.4 Rotatory Movement
  - 2.5 Hydrostatic Lift

3. Transport and Conservation of Mass, Momentum & Energy
  - 3.1 Kinematics of Fluids
  - 3.2 Continuity Equation
  - 3.3 Navier-Stokes Equations
  - 3.4 Energy Equation
  - 3.5 Diffusion and Dissipation
4. Flow Models of Incompressible Fluids
  - 4.1 One-dimensional Flows
  - 4.2 Bidimensional Frictionless Flows
  - 4.3 Bidimensional Flows with Friction
  - 4.4 Throughflows
5. Gas Dynamics
  - 5.1 Introduction to Gas Dynamics
  - 5.2 Basic Equations
  - 5.3 Stationary One-dimensional Case
  - 5.4 One-dimensional Case with Variable Cross Section
  - 5.5 Sonic Booms
6. Advanced Fluid Mechanics
  - 6.1 Dimensionless Balance Equations
  - 6.2 Computational Fluid Dynamics

**Literature****Compulsory Reading****Further Reading**

- Pozrikidis, C. (2016). Fluid dynamics: Theory, computation, and numerical simulation, third edition. Springer US
- Sharma, A. (2022). Introduction to Computational Fluid Dynamics. Springer International Publishing.
- Visconti, G., & Ruggieri, P. (2020). Fluid Dynamics. Springer International Publishing.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>		
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input type="checkbox"/> Slides	<input type="checkbox"/> Sprint <input checked="" type="checkbox"/> Interactive Online Lecture



## Simulation and Control of Robots

Module Code: DLBWINWMSSR\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> <ul style="list-style-type: none"> <li>▪ DLBROPMSR01_E</li> <li>▪ DLBROMK01_E,</li> <li>DLBROMD01_E</li> </ul>	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Project: Modeling and Simulation of Robots) / N.N. (Project: Introduction to Robot Control)

### Contributing Courses to Module

- Project: Modeling and Simulation of Robots (DLBROPMSR01\_E)
- Project: Introduction to Robot Control (DLBROPIRC01\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Project: Modeling and Simulation of Robots

- Study Format "myStudies": Written  
Assessment: Project Report
- Study Format "Distance Learning": Written  
Assessment: Project Report

##### Project: Introduction to Robot Control

- Study Format "Distance Learning": Written  
Assessment: Project Report
- Study Format "myStudies": Written  
Assessment: Project Report

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Project: Modeling and Simulation of Robots</b></p> <p>Mathematical modeling of robots will be seen from a practical perspective. The students will learn how to build a static or dynamic model of robots in a simulation environment, to perform design, testing, and analysis activities.</p> <p><b>Project: Introduction to Robot Control</b></p> <p>This course provides an introduction to the design of servo-level robot controllers. The students will learn how to set up a simulation model of a robot which considers the presence of actuators, sensors, and control systems. Standard control approaches will be tested and evaluated.</p>	
<p><b>Learning Outcomes</b></p> <p><b>Project: Modeling and Simulation of Robots</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ perform simulation of dynamic systems.</li> <li>▪ name issues related to the numeric simulation of continuous-time systems.</li> <li>▪ implement the dynamic model of a robot in a simulation environment.</li> <li>▪ generate and discuss valid simulation results .</li> </ul> <p><b>Project: Introduction to Robot Control</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand the lower levels of a robot control system.</li> <li>▪ name standard control approaches for robot motion.</li> <li>▪ implement the controllers and evaluate the performance in simulation .</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field of Engineering</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programmes in the IT &amp; Technology fields</p>

## Project: Modeling and Simulation of Robots

Course Code: DLBROPMSR01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBROMK01_E, DLBROMD01_E

### Course Description

Mathematical modeling of robots is very important to be able to perform design and analysis. In the context of industrial internet of things, or Industry 4.0, the building of a so-called digital twin by means of simulation models is a central activity to many other processes, such as real-time optimization of tasks as well as fault-detection and diagnosis. In this course the students will learn how a mathematical model can be implemented in a simulation environment, to perform analysis, design, and optimization.

### Course Outcomes

On successful completion, students will be able to

- perform simulation of dynamic systems.
- name issues related to the numeric simulation of continuous-time systems.
- implement the dynamic model of a robot in a simulation environment.
- generate and discuss valid simulation results .

### Contents

- The course provides the basics in simulation of dynamic systems and implementation of simulation models in computer-aided simulation environments. A simulation model for industrial or mobile robots is built and students will learn how to perform analysis of the model, and use it for design optimization.

### Literature

#### Compulsory Reading

#### Further Reading

- Corke, P. (2017). Robotics, Vision and Control: Fundamental Algorithms In MATLAB® (2nd ed.). Springer International Publishing, Basel.
- Klee, H., & Allen, R. (2017). Simulation of dynamic systems with MATLAB and Simulink (3rd ed.). CRC Press, Boca Raton, Florida.
- Russell, K., Shen, Q., & Sodhi, R. S. (2018). Kinematics and dynamics of mechanical systems : implementation in MATLAB and SimMechanics (2nd ed.). CRC Press, Boca Raton, Florida.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Project: Introduction to Robot Control

Course Code: DLBROPIRC01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBROPMSR01_E

### Course Description

Robot control allows a robot to perform the required task. Complex tasks, sometimes called missions, are subdivided into simpler subtasks that constitute elementary actions to be performed by the robot. The robot control system acts at different levels. This course focuses on the lower levels, which deal with the execution of elementary actions and are based on the real-time interaction of the robot system with the environment as well as with the actuators moving the joints. The students will learn how to implement and evaluate standard control approaches, such as Proportional-Integral-Derivative controllers, on a mathematical model of a robot.

### Course Outcomes

On successful completion, students will be able to

- understand the lower levels of a robot control system.
- name standard control approaches for robot motion.
- implement the controllers and evaluate the performance in simulation .

### Contents

- This course provides an introduction to the design of servo-level robot controllers. The students will learn how to set up a simulation model of a robot which considers the presence of actuators, sensors, and control systems. Standard control approaches will be tested and evaluated.

### Literature

#### Compulsory Reading

#### Further Reading

- Corke, P. (2017). Robotics, Vision and Control: Fundamental Algorithms In MATLAB® (2nd ed.). Springer International Publishing, Basel.
- Klee, H., & Allen, R. (2017). Simulation of dynamic systems with MATLAB and Simulink (3rd ed.). CRC Press, Boca Raton, Florida.
- Russell, K., Shen, Q., & Sodhi, R. S. (2018). Kinematics and dynamics of mechanical systems : implementation in MATLAB and SimMechanics (2nd ed.). CRC Press, Boca Raton, Florida.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



## Mechatronic Systems and Programming with C/C++

Module Code: DLBENGEMSPC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

N.N. (Mechatronic Systems) / Prof. Dr. Emanuele Grasso (Programming with C/C++)

### Contributing Courses to Module

- Mechatronic Systems (DLBROMSY01\_E)
- Programming with C/C++ (DLBROEPRS01\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Mechatronic Systems

- Study Format "myStudies": Exam, 90 Minutes
- Study Format "Distance Learning": Exam, 90 Minutes

##### Programming with C/C++

- Study Format "myStudies": Portfolio
- Study Format "Distance Learning": Portfolio

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Mechatronic Systems</b></p> <ul style="list-style-type: none"> <li>▪ Modeling</li> <li>▪ Electrical Drives</li> <li>▪ Machines and Drivetrains</li> <li>▪ Actuators and Sensors</li> </ul> <p><b>Programming with C/C++</b></p> <p>C and C++ for programming of applications and robots</p>	
<p><b>Learning Outcomes</b></p> <p><b>Mechatronic Systems</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand the basics of mathematical modeling of engineering systems.</li> <li>▪ model and simulate common mechatronic systems.</li> <li>▪ apply mechatronic systems for a given application.</li> <li>▪ understand the basics of actuators, sensors, and system integration.</li> </ul> <p><b>Programming with C/C++</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ know the main characteristics of C and C++ programming languages.</li> <li>▪ apply C and C++ for programming of applications.</li> <li>▪ apply C and C++ for programming of robotic systems.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the fields of Engineering and Computer Science &amp; Software Development</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the IT &amp; Technology fields</p>

# Mechatronic Systems

Course Code: DLBROMSY01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Numerous processes and products experience an increasing combination of traditional and advanced mechanics with electronics. Especially with information processing, this development leads to a so-called mechatronic system, with the purpose to improve overall performance. This course illustrates the development of mechatronics and focuses on some important aspects, such as modeling techniques (which are relevant for system simulation, design and optimization), common electric drives, machines and drivetrains, actuators and sensors.

## Course Outcomes

On successful completion, students will be able to

- understand the basics of mathematical modeling of engineering systems.
- model and simulate common mechatronic systems.
- apply mechatronic systems for a given application.
- understand the basics of actuators, sensors, and system integration.

## Contents

1. Introduction
  - 1.1 Mechatronic Systems
  - 1.2 Examples
2. Modeling
  - 2.1 Fundamental Equations
  - 2.2 Energy Balance
  - 2.3 Connection of Process Elements
  - 2.4 Dynamics of Mechanical Systems
  - 2.5 Mechanical Elements
3. Electrical Drives
  - 3.1 Electromagnets
  - 3.2 Direct Current Motors
  - 3.3 Alternating Current Motors

4. Machines and Drivetrains
4.1 Complete Machines
4.2 Characteristics and Stability of Machines
4.3 Motors and Pumps
4.4 Automobile Drivetrain
4.5 Signal Energy
4.6 Applications
5. Actuators and Sensors
5.1 Basic Structures
5.2 Electromechanical Drives
5.3 Hydraulic Actuators
5.4 Pneumatic Actuators
5.5 Unconventional Actuators

<b>Literature</b>
<b>Compulsory Reading</b>
<b>Further Reading</b>
<ul style="list-style-type: none"><li>▪ Boukas, E. K./Al-Sunni, F. M. (2012): Mechatronic systems: Analysis, design and implementation. Springer, Berlin.</li><li>▪ Davim, J. P. (2011): Mechatronics. John Wiley &amp; Sons, Hoboken, NJ.</li><li>▪ Isermann, R. (2005): Mechatronic systems: Fundamentals. Springer, London.</li><li>▪ Janschek, K./Richmond, K. (2012): Mechatronic systems design methods, models, concepts. Springer, Berlin</li></ul>

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Programming with C/C++

Course Code: DLBROEPRS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

C and C++ belong to the class of programming languages which have been adopted in a broad field of applications, ranging from embedded systems (where they are dominant) to fast and reliable user interfaces and industrial applications. In fact, C++ is one of the most popular legacy programming languages for robotics, and a combination of C++ and robotics hardware is used in many leading industries. Knowledge on how to design in and write C/C++ code is an imperative capability for the practicing roboticist, especially in the industrial arena.

### Course Outcomes

On successful completion, students will be able to

- know the main characteristics of C and C++ programming languages.
- apply C and C++ for programming of applications.
- apply C and C++ for programming of robotic systems.

### Contents

- This course introduces the main aspects of C and C++ programming languages, such as data types, variables, arithmetic expressions, flow control, functions, classes, arrays, and pointers. The programming skills will then be applied to design parts of robotic systems based on popular hardware.

### Literature

#### Compulsory Reading

#### Further Reading

- Kernighan, B. W. & Ritchie, D. M. (2000). The C Programming Language, Second Edition. Pearson Education.
- Lippman, S. B., Lajoie, J., Moo, B. (2012). C++ Primer, Fifth Edition. Addison Wesley.
- Margolis, M. (2011). Arduino Cookbook. O'Reilly Media.
- Dogan, I. (2021). Nucleo Boards Programming with the STM32CubeIDE. Elektor.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

DLBROEPRS01\_E

## Agile Project Management and Smart Products

Module Code: DLBENGEAPMSP

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

Prof. Dr. Inga Schlömer (Agile Project Management) / N.N. (Project: Smart Product Solutions)

### Contributing Courses to Module

- Agile Project Management (DLBCSAPM01)
- Project: Smart Product Solutions (DLBIEPSPS01)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Agile Project Management

- Study Format "myStudies": Written Assessment: Project Report
- Study Format "Distance Learning": Written Assessment: Project Report

##### Project: Smart Product Solutions

- Study Format "Distance Learning": Oral Project Report
- Study Format "myStudies": Oral Project Report

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Agile Project Management</b></p> <p>In this course, students are taught action competences in the field of agile project management. They will be familiarized with the values, activities, roles, and artifacts of agile procedures using Scrum as an example.</p> <p><b>Project: Smart Product Solutions</b></p> <p>This course focuses on the application of agile engineering methods for smart product solutions within the framework of a practice-oriented project. The architecture and mechanics of smart product solutions will be described by means of their integrated business model components.</p>	
<p><b>Learning Outcomes</b></p> <p><b>Agile Project Management</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ explain the differences between agile and plan-driven project management.</li> <li>▪ explain agile principles.</li> <li>▪ work together in an agile manner according to the values defined in Scrum.</li> <li>▪ apply the activities defined in Scrum.</li> <li>▪ take responsibility for the roles defined in Scrum.</li> <li>▪ create and maintain the artefacts defined in Scrum.</li> <li>▪ consider the increasing relevance of international, intercultural and virtual collaboration in projects.</li> </ul> <p><b>Project: Smart Product Solutions</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ answer the question of the relevance of dynamic business models of smart product solutions for business practice.</li> <li>▪ describe and analyze smart product solutions by means of the business model architecture and mechanics.</li> <li>▪ select and apply the right tools from the engineering methodology toolbox of smart product solutions for the modelling and analysis of digital business models in a practice-oriented way.</li> <li>▪ develop management cockpits to support decision-making in the implementation of smart product solutions.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the fields of Project Management and Computer Science &amp; Software Development</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the Business &amp; Management and IT &amp; Technology fields</p>

# Agile Project Management

Course Code: DLBCSAPM01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

Students will receive a practical introduction to agile project management in this course. In addition to teaching its individual basic principles, the differences between agile project management and plan-driven project management will be examined in detail. In order to understand and experience agile project management, the values, activities, roles, and artefacts of typical agile procedures are presented using Scrum and then practiced on an example project.

## Course Outcomes

On successful completion, students will be able to

- explain the differences between agile and plan-driven project management.
- explain agile principles.
- work together in an agile manner according to the values defined in Scrum.
- apply the activities defined in Scrum.
- take responsibility for the roles defined in Scrum.
- create and maintain the artefacts defined in Scrum.
- consider the increasing relevance of international, intercultural and virtual collaboration in projects.

## Contents

- This course teaches students various skills in the field of agile project management. In contrast to plan-driven project management, the principles of agility used in modern software development are taught. Using the example of Scrum, students will acquire skills in applying an agile approach, and then apply their knowledge of respective roles and activities in a simple project to gain initial practical experience, documenting it in a project report. The content of the projects results from the individual abilities and requirements of the students.

**Literature****Compulsory Reading****Further Reading**

- Apress.Agile Alliance (2021). Subway Map to Agile Practices. (URL: <https://www.agilealliance.org/agile101/subway-map-to-agile-practices/> [last accessed on 23.06.2021]).
- Beck, K. et al. (2001). Manifesto for Agile Software Development. (URL: <https://agilemanifesto.org/> [last accessed on 23.06.2021]).
- Chovanova, H. et al. (2020). Agile Project Management – What is It?:IEEE. In 18th International Conference on Emerging eLearning Technologies and Applications (ICETA), Emerging eLearning Technologies and Applications (ICETA), 2020 18th International Conference.
- Dalton, Jeff (2019). Great Big Agile. An OS for Agile Leaders.
- Douglass, B. P. (2016). Agile systems engineering. Morgan Kaufmann, p. 151-160
- Project Management Institute (2017). Agile Practice Guide. Project Management Institute.
- Measey P./Radtac (2015). Agile Foundations -Principles, Practices and Frameworks. BCS The Chartered Institute for IT, p. 131-140, p. 148-152.
- Schwaber, K./Sutherland, J. (2020). The Scrum Guide. (URL: <https://scrumguides.org/docs/scrumguide/v2020/2020-Scrum-Guide-US.pdf#zoom=100> [last accessed on 23.06.2021])

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides



## Project: Smart Product Solutions

Course Code: DLBIEPSPS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

Smart product solutions have the potential to increase the efficiency of existing business models in the context of digital transformation. In addition to the expansion and optimization of traditional business models, smart product solutions also create completely new business models, in which, for example, revenues are not linked to the transfer of ownership of the product, but to its use. In practice, however, the design and analysis of smart product solutions and their business models is difficult for many companies, as the complexity of these smart solutions results in insufficient methodological know-how. Against this background, the students apply various instruments and modelling tools to describe and analyze smart product solutions within the framework of a practice-oriented project.

### Course Outcomes

On successful completion, students will be able to

- answer the question of the relevance of dynamic business models of smart product solutions for business practice.
- describe and analyze smart product solutions by means of the business model architecture and mechanics.
- select and apply the right tools from the engineering methodology toolbox of smart product solutions for the modelling and analysis of digital business models in a practice-oriented way.
- develop management cockpits to support decision-making in the implementation of smart product solutions.

### Contents

- By means of an agile engineering approach, students learn about the complex interrelationships of smart product solutions in a project-oriented setting. In addition to the structural description, students also gain a comprehensive insight into the quantitative modeling of the dynamic interrelationships of smart product solutions and their business models at a specific product solution level. The consistent application of techniques and tools from the engineering construction kit of smart product solutions enables the development of new business models as well as the adaptation of existing business models through the flexible configuration of interdependent components. Radical innovations with a completely new benefits are just as possible as incremental adjustments in a more evolutionary transformation process. Through the abstract description of the architecture

and the dynamic modelling of the mechanics of the smart product solutions and their business models, students learn the basics for effective decision support in practice, which ensures continuous learning in a digital world with growing dynamic complexity.

#### Literature

#### Compulsory Reading

#### Further Reading

- Avlonitis, V. (2013): PSS readiness manual. A workbook in the PROTEUS series: # 3. 1st edition, Kongens Lyngby: Technical University of Denmark.
- Bejbro Andersen, J. (2013): PSS business models. A workbook in the PROTEUS series: # 7. 1st edition, Kongens Lyngby: Technical University of Denmark.
- Meier, H./Boßlau, M. (2013): Design and Engineering of Dynamic Business Models for Industrial Product-Service Systems. In Y. Shimomura & K. Kimita (Eds.), Lecture Notes in Production Engineering. The Philosopher's Stone for Sustainability: Proceedings of the 4th CIRP International Conference on Industrial Product-Service Systems, Tokyo, Japan, November 8th - 9th, 2012 (pp. 179–184). Springer, Berlin, Heidelberg.
- Sakao, T./Lindahl, M. (2009): Introduction to Product/Service-System Design. Springer, London.
- Zawadzki, P./Żywicki, K. (2016): Smart Product Design and Production Control for Effective Mass Customization in the Industry 4.0 Concept. Management and Production Engineering Review, 7(3), 105–112.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Oral Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Oral Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

## Pentesting and DevSecOps

Module Code: DLBENGEPD

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> <ul style="list-style-type: none"> <li>▪ none</li> <li>▪ DLBCSESPB01_E or DLBCSESPB01_D</li> </ul>	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b>
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Prof. Dr. Jesus Luna Garcia (System Pentesting Basics) / N.N. (DevSecOps and Common Software Weaknesses)

### Contributing Courses to Module

- System Pentesting Basics (DLBCSESPB01\_E)
- DevSecOps and Common Software Weaknesses (DLBCSEDCSW01\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### System Pentesting Basics

- Study Format "myStudies": Exam, 90 Minutes
- Study Format "Distance Learning": Exam, 90 Minutes

##### DevSecOps and Common Software Weaknesses

- Study Format "myStudies": Written Assessment: Written Assignment
- Study Format "Distance Learning": Written Assessment: Written Assignment

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>System Pentesting Basics</b></p> <ul style="list-style-type: none"> <li>▪ Penetration testing process</li> <li>▪ Host-based penetration testing</li> <li>▪ Exploitation of network services</li> <li>▪ Web App penetration testing</li> <li>▪ System hardening</li> <li>▪ Ethical hacking</li> </ul> <p><b>DevSecOps and Common Software Weaknesses</b></p> <ul style="list-style-type: none"> <li>▪ Common code bugs</li> <li>▪ Software Development Lifecycle</li> <li>▪ DevOps</li> <li>▪ DevSecOps</li> <li>▪ Vulnerability reporting and bug bounty programs</li> <li>▪ Patch management</li> </ul>	
<p><b>Learning Outcomes</b></p> <p><b>System Pentesting Basics</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand the basic organizational and compliance needs for penetration testing.</li> <li>▪ identify the relevant components of modern-day IT system that may be exploitable.</li> <li>▪ understand the underlying processes comprising a penetration testing.</li> <li>▪ understand the most common attack vectors associated to hosts, networks and Web Apps as well as how to defend against those.</li> <li>▪ familiarize themselves with real-world tools used by professional penetration testers.</li> </ul> <p><b>DevSecOps and Common Software Weaknesses</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ avoid common software implementation and design mistakes.</li> <li>▪ design a software development lifecycle process based on DevSecOps principles.</li> <li>▪ incorporate vulnerability reporting and response into the SDL.</li> <li>▪ organize and manage a bug bounty program.</li> <li>▪ implement and manage a corporate patch management process.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the fields of Computer Science &amp; Software Development</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the IT &amp; Technology fields</p>

# System Pentesting Basics

Course Code: DLBCSESPB01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

System penetration testing is a vital process for finding and supporting the mitigation of vulnerabilities in IT systems before the attackers can exploit them. For that reason, many organizations employ such “pentesters”, or ethical hackers, to test their software and hardware base (connectivity included) and fix the security issues that are found. This has become a cornerstone of modern security concepts. However, in order to be successful in this endeavor, a good knowledge of the different types of targeted IT systems is required. We refer to hosts, networks, Web Apps, and even cloud computing. In this course we present the fundamental aspects of IT systems, along with the processes, tools and techniques that comprise the industrial practice of penetration testing. Equipped with this knowledge, students will understand the mechanisms of a given attack, and start down the path of pentesting themselves.

## Course Outcomes

On successful completion, students will be able to

- understand the basic organizational and compliance needs for penetration testing.
- identify the relevant components of modern-day IT system that may be exploitable.
- understand the underlying processes comprising a penetration testing.
- understand the most common attack vectors associated to hosts, networks and Web Apps as well as how to defend against those.
- familiarize themselves with real-world tools used by professional penetration testers.

## Contents

1. Penetration Testing Goals and Industrial Perspective
  - 1.1 Organizational Benefits
  - 1.2 Ethical Hacking Framework
  - 1.3 Legal and Compliance Aspects
  - 1.4 Responsible Disclosure of Vulnerabilities
  - 1.5 Professional Penetration Testing Services and Certifications

2. Background Concepts
  - 2.1 Operating Systems
  - 2.2 Hardware Architectures
  - 2.3 Networking and Protocols
  - 2.4 Web-Based Applications
  - 2.5 Cloud Computing
3. Penetration Testing Process
  - 3.1 Planning and Reconnaissance
  - 3.2 Whitebox, Blackbox and Graybox Scanning
  - 3.3 Gaining Access
  - 3.4 Maintaining Access
  - 3.5 Analysis and Reporting
  - 3.6 Hardening and Mitigation
4. Operating System-Based Penetration Testing
  - 4.1 Common Misconfigurations
  - 4.2 Shellcode Attacks
  - 4.3 Memory Corruption and Buffer Overflow Vulnerabilities
  - 4.4 Metasploit and Kali Tools
  - 4.5 Operating System Hardening
5. Network Penetration Testing
  - 5.1 Network Infrastructure Scoping and Recon
  - 5.2 Exploiting Network Services
  - 5.3 Lateral Movement in the Network
  - 5.4 Kerberos Attacks
  - 5.5 Toolset: Nmap, PowerShell, Bloodhound, and Tcpdump
  - 5.6 Devising Corrective Actions
6. Web App Penetration Testing
  - 6.1 The OWASP Methodology
  - 6.2 Open Source Intelligence (OSINT)
  - 6.3 Commonly Exploited Web App Vulnerabilities
  - 6.4 Exploitation Toolset: BurpSuite, sqlmap, BeEF and ExploitDB
  - 6.5 Reporting Findings and Mitigation Actions



7. Specialized Penetration Testing at a Glance
  - 7.1 Exploit Development
  - 7.2 Ethical Hacking
  - 7.3 Wireless and Mobile Device Penetration Testing
  - 7.4 Cloud Threat and Vulnerability Assessment

**Literature****Compulsory Reading****Further Reading**

- Erickson, J. (2007): Hacking. The Art of Exploitation. No Starch Press, San Francisco.
- Gollmann, D. (2011): Computer Security. 3rd edition, Wiley, Hoboken, NJ.
- Kim, P. (2014): The Hacker Playbook. A Practical Guide to Penetration Testing. CreateSpace Independent Publishing Platform, North Charleston.
- Lin, X. (2018): Introductory Computer Forensics. A Hands-on Practical Approach. Springer International Publishing, Cham.
- Stuttard, D. (2011): The Web Application Hacker's Handbook. Finding and Exploiting Security Flaws. Wiley, Hoboken, NJ.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## DevSecOps and Common Software Weaknesses

Course Code: DLBCSEDCSW01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBCSESPB01_E or DLBCSESPB01_D

### Course Description

Modern organizations are run by software to some degree or another. In many cases, it is the custom software in business processes or products that is the key differentiator. But even companies that do no development of their own, are dependent on software and understanding software vulnerabilities is vital to their operations, as recent ransomware attacks have shown. In this course, we look at modern software development and lifecycle processes. Since its beginnings with Extreme Programming, there has been a shift away from the waterfall design to an agile development process. More recently, the Shift-Left movement has advocated for security to be considered from the start and not as an afterthought. In order to design secure software, it is naturally important to understand how insecurities creep into code. We look at the most important enumerations of software bugs: OWASP and Mitre's CWEs. Lastly, patch management has become the most important defensive tool for an organization. We look at this topic both from a software development perspective as well as from the customer's point of view.

### Course Outcomes

On successful completion, students will be able to

- avoid common software implementation and design mistakes.
- design a software development lifecycle process based on DevSecOps principles.
- incorporate vulnerability reporting and response into the SDL.
- organize and manage a bug bounty program.
- implement and manage a corporate patch management process.

### Contents

1. Introduction to the software development process
  - 1.1 Traditional software development: Waterfall design
  - 1.2 Iterative design
  - 1.3 Agile software development
  - 1.4 Operations as a separate process
  - 1.5 Infrastructure as code
  - 1.6 Merging Development and Operations: DevOps

2. DevOps best practices
  - 2.1 Coding: code development and review, source code management tools, code merging.
  - 2.2 Building: continuous integration tools, build status.
  - 2.3 Testing: continuous testing tools that provide quick and timely feedback on business risks.
  - 2.4 Packaging: artifact repository, application pre-deployment staging.
  - 2.5 Releasing: change management, release approvals, release automation.
  - 2.6 Configuring: infrastructure configuration and management, infrastructure as code tools.
  - 2.7 Monitoring: applications performance monitoring, end-user experience.
3. Sources of security bugs
  - 3.1 General classes of bugs
  - 3.2 Looking at the OWASP top ten
  - 3.3 Looking at the Mitre CWE™
4. DevSecOps
  - 4.1 Protection goals
  - 4.2 Threat modeling
  - 4.3 Choice of programming language, tool chain and infrastructure
  - 4.4 Linting for code security issues
  - 4.5 Testing for security
  - 4.6 Security by design/Shifting Left
  - 4.7 Security as a people problem
  - 4.8 Designing in a bug reporting and response process
  - 4.9 Managing a bug bounty program
5. Patch management
  - 5.1 Dilemma: software update churn vs security
  - 5.2 Vulnerability disclosures and the Mitre CVE™ process
  - 5.3 Coordinated vulnerability disclosure
  - 5.4 Program security vs Software-as-a-Service patching
  - 5.5 Deployment strategies for catching bugs early
6. Summary and research problems

<b>Literature</b>
<b>Compulsory Reading</b>
<b>Further Reading</b> <ul style="list-style-type: none"><li>▪ Anderson, R. (2020): Security Engineering. 3rd edition, Wiley, Hoboken, NJ.</li><li>▪ Mitre CVEs: <a href="https://cwe.mitre.org">https://cwe.mitre.org</a></li><li>▪ OWASP Top-ten: <a href="https://owasp.org/www-project-top-ten/">https://owasp.org/www-project-top-ten/</a></li></ul>

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Written Assignment

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Written Assignment

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



# Machine Learning - Supervised and Unsupervised Learning

Module Code: DLBENGEMLSUL

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLBDSMFC01, DLBDSMFLA01, DLBDSSPDS01, DLBDSSIS01	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

## Module Coordinator

Prof. Dr. Christian Müller-Kett (Machine Learning - Supervised Learning) / Prof. Dr. Christian Müller-Kett (Machine Learning - Unsupervised Learning and Feature Engineering)

## Contributing Courses to Module

- Machine Learning - Supervised Learning (DLBDSMLS01)
- Machine Learning - Unsupervised Learning and Feature Engineering (DLBDSMLUS01)

## Module Exam Type

### Module Exam

### Split Exam

#### Machine Learning - Supervised Learning

- Study Format "myStudies": Exam, 90 Minutes
- Study Format "Distance Learning": Exam, 90 Minutes

#### Machine Learning - Unsupervised Learning and Feature Engineering

- Study Format "Distance Learning": Written Assessment: Case Study
- Study Format "myStudies": Written Assessment: Case Study

**Weight of Module**

see curriculum

**Module Contents****Machine Learning - Supervised Learning**

- Types of machine learning
- Classification
- Regression
- Support vector machines
- Decision trees

**Machine Learning - Unsupervised Learning and Feature Engineering**

- Unsupervised machine learning
- Clustering
- Dimensionality reduction
- Manifold learning
- Feature engineering
- Feature selection
- Automation of feature generation and selection

**Learning Outcomes****Machine Learning - Supervised Learning**

On successful completion, students will be able to

- remember central notions and paradigms of machine learning.
- describe the key ideas of regression and pertaining regularization methods.
- know basic classification techniques.
- explain tree structured machine learning models.
- understand support vector machines and the related kernel approach.

**Machine Learning - Unsupervised Learning and Feature Engineering**

On successful completion, students will be able to

- explain the notions of unsupervised learning and feature selection.
- recall commonly-applied clustering models.
- understand the concept and utility of dimensionality reduction and manifold learning.
- describe effective approaches to feature engineering.
- discuss the methods of automatic feature generation and selection.
- reflect on societal and sustainability implications of applying the learned skills to different use cases including ethical questions.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Data Science & Artificial Intelligence

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology fields

## Machine Learning - Supervised Learning

Course Code: DLBDSM LSL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBDSMFC01, DLBDSMFLA01, DLBDSSPDS01, DLBDSSIS01

### Course Description

This course provides a first introduction to the field of machine learning with a focus on supervised learning (i.e., learning from labeled data), where the most commonly used models in regression and classification are being introduced. Moreover, the course provides an introduction to the concepts of large margin classifiers and tree structured models.

### Course Outcomes

On successful completion, students will be able to

- remember central notions and paradigms of machine learning.
- describe the key ideas of regression and pertaining regularization methods.
- know basic classification techniques.
- explain tree structured machine learning models.
- understand support vector machines and the related kernel approach.

### Contents

1. Introduction to Machine Learning
  - 1.1 Pattern recognition systems
  - 1.2 The machine learning design cycle
  - 1.3 Technical notions of learning and adaptation
  - 1.4 Under- and overfitting
2. Regression
  - 2.1 Linear regression
  - 2.2 Lasso- and ridge Regularization
  - 2.3 Generalized linear models
  - 2.4 Logistic regression
3. Basic Classification Techniques
  - 3.1 K-nearest neighbour
  - 3.2 Naïve Bayes

4. Support Vector Machines
  - 4.1 Large margin classification
  - 4.2 The kernel trick
5. Decision & Regression Trees
  - 5.1 Decision & regression trees
  - 5.2 Random forest
  - 5.3 Gradient boosting

**Literature****Compulsory Reading****Further Reading**

- Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
- Grus, J. (2019). Data science from scratch: First principles with Python (2nd ed.). O'Reilly.
- Mitchell, T. M. (1997). Machine learning. McGraw-Hill.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
------------------------------------------	--------------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Machine Learning - Unsupervised Learning and Feature Engineering

Course Code: DLBDSMLUSL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBDSMFC01, DLBDSMFLA01, DLBDSSPDS01, DLBDSSIS01

### Course Description

This course is concerned with the tools and techniques for unsupervised learning and feature engineering. Unsupervised learning denotes machine learning approaches that can be applied without label information. As such, the aim is to extract patterns or statistical regularities in data, and finding good features is key for the successful application of machine learning models. Therefore, having a solid set of approaches and tools for this task is of crucial importance for any data scientist. This course introduces the most relevant methods and shows how unsupervised learning techniques can be utilized to find robust and meaningful features. By doing so, concepts and techniques are demonstrated by tangible examples which reflect usage of these techniques to generate added value for the society as a whole as opposed to ethical questionable use cases.

### Course Outcomes

On successful completion, students will be able to

- explain the notions of unsupervised learning and feature selection.
- recall commonly-applied clustering models.
- understand the concept and utility of dimensionality reduction and manifold learning.
- describe effective approaches to feature engineering.
- discuss the methods of automatic feature generation and selection.
- reflect on societal and sustainability implications of applying the learned skills to different use cases including ethical questions.

### Contents

1. Introduction to Unsupervised Machine Learning and Feature Engineering
  - 1.1 Unsupervised machine learning
  - 1.2 Feature engineering
2. Clustering
  - 2.1 K-Means
  - 2.2 Gaussian mixture model clustering
  - 2.3 Hierarchical clustering



3. Dimensionality Reduction
  - 3.1 Principal component analysis
  - 3.2 Multi-dimensional scaling
  - 3.3 Locally linear embedding
4. Feature Engineering
  - 4.1 Numerical features
  - 4.2 Categorical features
  - 4.3 Text features
5. Feature Selection
  - 5.1 Feature importance
  - 5.2 Feature variance
  - 5.3 Correlation matrix
  - 5.4 Recursive feature selection
6. Automated Feature Generation
  - 6.1 Automated feature generation
  - 6.2 Feature engineering versus deep learning

## Literature

### Compulsory Reading

### Further Reading

- Bonaccorso, G. (2019). Hands-on unsupervised learning with Python: Implement machine learning and deep learning models using Scikit-Learn, TensorFlow, and more. Packt Publishing Ltd.
- Celebi, M. E., & Aydin, K. (Eds.). (2016). Unsupervised learning algorithms. Springer International Publishing.
- Kane, F. (2017). Hands-on data science and Python machine learning. Packt Publishing Ltd.
- Patel, A. A. (2019). Hands-on unsupervised learning using Python: How to build applied machine learning solutions from unlabeled data. O'Reilly Media.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Case Study
------------------------------------------	----------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Case Study

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Case Study
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Case Study

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBDSMLUSL01

## Autonomous Driving

Module Code: DLBDSEAD

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	10	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

N.N. (Self-Driving Vehicles) / N.N. (Seminar: Current Topics and Trends in Self-Driving Technology)

### Contributing Courses to Module

- Self-Driving Vehicles (DLBDSEAD01)
- Seminar: Current Topics and Trends in Self-Driving Technology (DLBDSEAD02)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Self-Driving Vehicles

- Study Format "Distance Learning": Exam, 90 Minutes

##### Seminar: Current Topics and Trends in Self-Driving Technology

- Study Format "Distance Learning": Written Assessment: Research Essay

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Self-Driving Vehicles</b></p> <ul style="list-style-type: none"> <li>▪ Safety standards</li> <li>▪ Sensor fusion</li> <li>▪ Computer vision</li> <li>▪ Localization &amp; motion</li> <li>▪ Motion planning</li> </ul> <p><b>Seminar: Current Topics and Trends in Self-Driving Technology</b></p> <p>The seminar covers current topics of autonomous vehicles. The choice of topics can include (but are not limited to) recent technical advances as well as philosophical issues or implications for society, law, or relevant industries.</p>	
<p><b>Learning Outcomes</b></p> <p><b>Self-Driving Vehicles</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ cite relevant safety standards.</li> <li>▪ grasp the concepts of sensors and sensor fusion.</li> <li>▪ apply computer vision techniques to detect features.</li> <li>▪ evaluate images in terms of semantic segmentation.</li> <li>▪ understand motion models and localization approaches.</li> <li>▪ utilize motion planning techniques.</li> </ul> <p><b>Seminar: Current Topics and Trends in Self-Driving Technology</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ transfer theoretical knowledge and methods to new domains.</li> <li>▪ understand recent developments in self-driving vehicles.</li> <li>▪ create new insights based on detailed studies of current research and technology.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field of Engineering</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programmes in the IT &amp; Technology fields</p>

# Self-Driving Vehicles

Course Code: DLBDSEAD01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

This course focuses on the foundations of autonomous vehicles and starts with a detailed introduction to relevant safety standards in terms of functional and IT security. This course continues with a presentation of the concept of sensor fusion and discusses relevant aspects of computer vision techniques such as feature detection, calibration, and semantic segmentation. A large part of the course concerns localization and motion planning. Relevant motion models are introduced and localization techniques such as odometry, triangulation, and satellite-based systems are discussed in detail, along with path planning, motion prediction, and trajectory generation.

## Course Outcomes

On successful completion, students will be able to

- cite relevant safety standards.
- grasp the concepts of sensors and sensor fusion.
- apply computer vision techniques to detect features.
- evaluate images in terms of semantic segmentation.
- understand motion models and localization approaches.
- utilize motion planning techniques.

## Contents

1. Sensors
  - 1.1 Physical principles of sensors
  - 1.2 Types of sensors
  - 1.3 Sensor calibration
  - 1.4 Application scenarios
2. Sensor Fusion
  - 2.1 Elaborating data from sensors
  - 2.2 Kalman filter
  - 2.3 Object tracking

3. Computer Vision
  - 3.1 Pixels and filters
  - 3.2 Feature detection
  - 3.3 Distortions and calibration
  - 3.4 Semantic segmentation
4. Localization & Motion
  - 4.1 Motion models
  - 4.2 Odometry
  - 4.3 Triangulation
  - 4.4 Satellite-based localization
5. Motion planning
  - 5.1 Path planning
  - 5.2 Motion prediction
  - 5.3 Trajectory generation
6. Safety Standards
  - 6.1 Functional Safety
  - 6.2 IT Security Standards
  - 6.3 Safety development approaches



**Literature****Compulsory Reading****Further Reading**

- Ben-Ari, M./Mondada, F. (2018): Elements of robotics. Springer, Cham.
- European Union. (2001): Directive 2001/95/EG. (URL: <https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=CELEX%3A32001L0095> [Retrieved: 28.02.2020])
- Fisher, R. B., et al. (2016): Dictionary of computer vision and image processing. John Wiley & Sons, Chichester.
- International Electrotechnical Commission. (2015): IEC 61508. (URL: <https://www.iec.ch/functionalsafety/> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2009): ISO 15408. (URL: <https://www.iso.org/standard/50341.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2018): ISO 25119. (URL: <https://www.iso.org/standard/69026.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2018): ISO 26262. (URL: <https://www.iso.org/standard/68383.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (n.d.): ISO 21434. (URL: <https://www.iso.org/standard/70918.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2018): ISO/IEC 27001. (URL: <https://www.iso.org/isoiec-27001-information-security.html> [Retrieved: 28.02.2020])
- Rausand, M. (2014): Reliability of safety-critical systems: Theory and applications. Wiley, Hoboken, NJ.
- Smith, D. J./Simpson, K. (2016): The safety critical systems handbook. 4th ed., Elsevier, Oxford.
- Smith, D. J. (2017): Reliability, maintainability and risk. 9th ed., Elsevier, Oxford.
- Society of Automobile Engineers International. (2012): SAE J3061. (URL: <https://www.sae.org/standards/content/j3061/> [Retrieved: 28.02.2020])
- Szelski, R. (2011): Computer vision: Algorithms and applications. 2nd ed., Springer VS, Wiesbaden.
- Wang, P. K.-C. (2015): Visibility-based optimal path and motion planning (vol. 568). Springer, Cham.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Seminar: Current Topics and Trends in Self-Driving Technology

Course Code: DLBDSEAD02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

This course focuses on recent developments in the field of self-driving vehicles. Following the course Self-Driving Vehicles (DLBDSEAD01), in this course students will focus on a particular topic in the context of autonomous driving, applying the knowledge they have obtained in the first course. Finally, a research essay will be written.

### Course Outcomes

On successful completion, students will be able to

- transfer theoretical knowledge and methods to new domains.
- understand recent developments in self-driving vehicles.
- create new insights based on detailed studies of current research and technology.

### Contents

- The seminar covers current topics of autonomous vehicles. The choice of topics can include (but are not limited to) recent technical advances as well as philosophical issues or implications for society, law, or relevant industries.

**Literature****Compulsory Reading****Further Reading**

- Ben-Ari, M./Mondada, F. (2018): Elements of robotics. Springer, Cham.
- European Union. (2001): Directive 2001/95/EG. (URL: <https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=CELEX%3A32001L0095> [Retrieved: 28.02.2020])
- Fisher, R. B., et al. (2016): Dictionary of computer vision and image processing. John Wiley & Sons, Chichester.
- International Electrotechnical Commission. (2015): IEC 61508. (URL: <https://www.iec.ch/functionalsafety/> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2009): ISO 15408. (URL: <https://www.iso.org/standard/50341.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2018): ISO 25119. (URL: <https://www.iso.org/standard/69026.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2018): ISO 26262. (URL: <https://www.iso.org/standard/68383.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (n.d.): ISO 21434. (URL: <https://www.iso.org/standard/70918.html> [Retrieved: 28.02.2020])
- International Organization for Standardization. (2018): ISO/IEC 27001. (URL: <https://www.iso.org/isoiec-27001-information-security.html> [Retrieved: 28.02.2020])
- Marchthaler, R./Dingler, S. (2017): Kalman-Filter. Springer, Wiesbaden.
- Rausand, M. (2014): Reliability of safety-critical systems: Theory and applications. Wiley, Hoboken, NJ.
- Smith, D. J./Simpson, K. (2016): The safety critical systems handbook. 4th ed., Elsevier, Oxford.
- Smith, D. J. (2017): Reliability, maintainability and risk. 9th ed., Elsevier, Oxford.
- Society of Automobile Engineers International. (2012): SAE J3061. (URL: <https://www.sae.org/standards/content/j3061/> [Retrieved: 28.02.2020])
- Szelski, R. (2011): Computer vision: Algorithms and applications. 2nd ed., Springer VS, Wiesbaden.
- Wang, P. K.-C. (2015): Visibility-based optimal path and motion planning (vol. 568). Springer, Cham.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Seminar
------------------------------------------	-------------------------------

<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Research Essay

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

DLBDSEAD02

# Embedded Systems, Microcontrollers and Logical Circuits

Module Code: DLBENGEEESMLC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	<ul style="list-style-type: none"> <li>▪ DLBAETDIT01_E</li> <li>▪ none</li> </ul>	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

## Module Coordinator

N.N. (Embedded Systems) / Prof. Dr. Marian Benner-Wickner (Project: Microcontrollers and Logical Circuits)

## Contributing Courses to Module

- Embedded Systems (DLBROES01\_E)
- Project: Microcontrollers and Logical Circuits (DLBAETPMLS01\_E)

## Module Exam Type

Module Exam	Split Exam
	<p><u>Embedded Systems</u></p> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Exam, 90 Minutes</li> <li>• Study Format "Distance Learning": Exam, 90 Minutes</li> </ul> <p><u>Project: Microcontrollers and Logical Circuits</u></p> <ul style="list-style-type: none"> <li>• Study Format "Distance Learning": Oral Project Report</li> </ul>

## Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Embedded Systems</b></p> <ul style="list-style-type: none"> <li>▪ Embedded systems architecture</li> <li>▪ Embedded hardware</li> <li>▪ Embedded software</li> <li>▪ Embedded Operating Systems</li> <li>▪ Distributed systems and IoT architecture</li> </ul> <p><b>Project: Microcontrollers and Logical Circuits</b></p> <p>The students should work independently through the complete flow of logic circuit design on the basis of a given problem. This includes the following steps: setting up a concept, module/ component design, programming the modules, simulation and testing/implementation on a development board.</p>	
<p><b>Learning Outcomes</b></p> <p><b>Embedded Systems</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ understand the architecture of embedded systems.</li> <li>▪ understand real-time embedded systems.</li> <li>▪ design the main architecture of embedded systems for robotics, automation and IoT infrastructure.</li> </ul> <p><b>Project: Microcontrollers and Logical Circuits</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ link the theoretical knowledge acquired in previous courses and apply it to a practical problem.</li> <li>▪ independently plan solutions for simple digital circuits.</li> <li>▪ successfully apply industry-used logic circuit design tools or use microcontroller programming tools.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the field of Engineering</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the IT &amp; Technology field</p>



# Embedded Systems

Course Code: DLBROES01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

To realize working engineering systems, embedded systems are required. Through embedding microprocessor-based systems capable of networking, data exchange and processing, the functionality of products and systems can be enhanced in terms of features, precision, accuracy, dynamic properties, intelligence. Actually, an embedded system is where everything begins. This course provides the basics on embedded system, by focusing on the architectural patterns of modern systems and platforms. The embedded hardware and software aspects are addressed. This course also introduces connectivity and networking aspects, which are required to build distributed systems for the internet of things and the industrial internet of things (finally yielding Cyber-Physical Systems).

## Course Outcomes

On successful completion, students will be able to

- understand the architecture of embedded systems.
- understand real-time embedded systems.
- design the main architecture of embedded systems for robotics, automation and IoT infrastructure.

## Contents

1. Introduction
  - 1.1 Embedded Systems Overview
  - 1.2 Hardware Elements of an Embedded System
  - 1.3 Standards, Compilers and Programming Languages
2. Elements of a Microcontroller
  - 2.1 Central Processing Units
  - 2.2 Volatile and non-volatile memory
  - 2.3 Digital/Analog Input/Output
  - 2.4 Timing peripherals
  - 2.5 Communication peripherals

3. Programming a Microcontroller
  - 3.1 Bone Structure of a Microcontroller Software
  - 3.2 Low-Level Programming
  - 3.3 Usage of Middle-Level Libraries
  - 3.4 Common IDEs and Tools
4. Embedded Operating Systems
  - 4.1 Task Management
  - 4.2 Scheduler
  - 4.3 Examples of Embedded Operating Systems
5. Distributed Systems and IoT Architecture
  - 5.1 Network Interfaces
  - 5.2 The Internet Protocol
  - 5.3 Examples of Distributed Systems

## Literature

### Compulsory Reading

### Further Reading

- Barkalov, A./Titarenko, L./Mazurkiewicz, M. (2019): Foundations of Embedded Systems. In: Kacprzyk, J.: Studies in Systems, Decision and Control, Volume 195, Springer Nature, Chams.
- Lacamera, D. (2018): Embedded systems architecture: explore architectural concepts, pragmatic design patterns, and best practices to produce robust systems. Packt Publishing, Birmingham.
- Noergaard, T. (2013): Embedded Systems Architecture. Elsevier Inc, Amsterdam.
- Siegesmund, M. (2014): Embedded C Programming. Elsevier Inc, Amsterdam.
- Simon, D. E. (1999): An embedded software primer. Addison Wesley, Boston, MS.
- White, E. (2011): Making Embedded Systems. O'Reilly, Sebastopol, CL.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Project: Microcontrollers and Logical Circuits

Course Code: DLBAETPMLS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBAETDIT01_E

### Course Description

The "Project: Microcontrollers and Logic Circuits" is intended to give students the opportunity to combine previously acquired knowledge of digital circuits with practical skills and to apply it to new problems. The handling of microcontrollers and logic circuits is a key qualification for many jobs in industry. In many electronic products with limited functionality, microcontrollers are used because of their special advantages. In edge computing, image processing, prototypes for communication networks and also for the realization of artificial intelligence, logic circuits are often used, either to provide a fast result or to meet special requirements. The "Project: Microcontroller and Logic Circuits" gives students the chance to develop their own microcontroller application or logic circuit.

### Course Outcomes

On successful completion, students will be able to

- link the theoretical knowledge acquired in previous courses and apply it to a practical problem.
- independently plan solutions for simple digital circuits.
- successfully apply industry-used logic circuit design tools or use microcontroller programming tools.

### Contents

- In the "Project: Microcontroller and Logic Circuits" the students have to work through the programming of an application on a microcontroller or the complete flow of the design of logic circuits independently on the basis of a given problem. The students will be given a catalog of possible problems. It is up to the students whether they solve the problem by a microcontroller application or by a logic circuit.
- The problems are supposed to be simple tasks as they are often encountered in industry, for example the reading of a sensor and conditional switching of an output, if a certain temperature, acceleration or light intensity is measured. Alternatively, interested students should also have the opportunity to contribute their own problems. In solving the problems, the students combine what they have learned in previous lectures with practical skills that they will acquire while working on the project. In addition tools will be applied that are also used in industry when working on the project.
- By the end of the project, students will have independently developed their own microcontroller application or a separate logic circuit will be implemented.

- If the students decide to solve their project with a microcontroller application, the steps to be carried out as well as the report to be submitted should include the following points:
  - Developing a concept for solving the problem: Based on the problem, students should develop a concept and document how the problem can be solved with a microcontroller.
  - Familiarization with the programming of microcontrollers: Based on their knowledge of the Python programming language, students will learn how to program microcontrollers using C++ and document their progress.
  - Transfer the concept into functional blocks and functions: Students decompose their concept into individual functional blocks and functions. They describe the interfaces between the blocks and the flow of the functions.
  - Implementing the code: Students program all functions. The procedure is documented and discussed.
  - Testing of the project on the target hardware (e.g. MikroElektronika MIKROE-483) and creation of the project documentation: Finally, the functionality of the solution is verified on a development board.
- Should students decide to solve their project with a logic circuit, then the steps to be taken, as well as the report to be submitted, should include the following points:
  - Developing a concept for solving the problem: Based on the problem, students should develop a concept and document how the problem can be solved with a logic circuit.
  - Translating the concept into a logical circuit at module/component level: The students break down their concept into individual components and describe the interfaces between the components, as well as the functional flow within the components.
  - Programming the modules: The previously specified components are programmed by the students in VHDL.
  - Simulation of the logic circuit: Testbenches are created for the individual components, as well as for the overall system, and their function is simulated. The results are documented and discussed.
  - Testing the project on the target hardware (e.g. Seeed Spartan Edge Accelerator Board - Arduino FPGA Shield) and creating the project documentation: Finally, the functionality of the solution is verified on a development board.
- Ideally, the students will work off, within the framework of the "Project: Microcontroller and logical circuits", all the points mentioned above for a solution path of their choice.

**Literature****Compulsory Reading****Further Reading**

- Parab, J./Shelake, V./Kamat, R./Naik, G. (2007): Exploring C for Microcontrollers: A Hands on Approach. 1st edition, Springer Netherlands, Dordrecht
- LaMeres, B. J. (2016): Introduction to Logic Circuits & Logic Design with VHDL. Springer International Publishing, Basel.
- LaMeres, B. J. (2019): Quick Start Guide to VHDL. Springer International Publishing, Basel.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Oral Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides



## Embedded Systems and Programming with C/C++

Module Code: DLBENGEESPC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

### Module Coordinator

N.N. (Embedded Systems) / Prof. Dr. Emanuele Grasso (Programming with C/C++)

### Contributing Courses to Module

- Embedded Systems (DLBROES01\_E)
- Programming with C/C++ (DLBROEPRS01\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Embedded Systems

- Study Format "myStudies": Exam, 90 Minutes
- Study Format "Distance Learning": Exam, 90 Minutes

##### Programming with C/C++

- Study Format "myStudies": Portfolio
- Study Format "Distance Learning": Portfolio

### Weight of Module

see curriculum

**Module Contents****Embedded Systems**

- Embedded systems architecture
- Embedded hardware
- Embedded software
- Distributed systems and IoT architecture
- Embedded operating systems

**Programming with C/C++**

- C and C++ for programming of applications and robots

**Learning Outcomes****Embedded Systems**

On successful completion, students will be able to

- understand the architecture of embedded systems.
- understand real-time embedded systems.
- design the main architecture of embedded systems for robotics, automation and IoT infrastructure.

**Programming with C/C++**

On successful completion, students will be able to

- know the main characteristics of C and C++ programming languages.
- apply C and C++ for programming of applications.
- apply C and C++ for programming of robotic systems.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Engineering and Computer Science & Software Development

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology fields

# Embedded Systems

Course Code: DLBROES01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

To realize working engineering systems, embedded systems are required. Through embedding microprocessor-based systems capable of networking, data exchange and processing, the functionality of products and systems can be enhanced in terms of features, precision, accuracy, dynamic properties, intelligence. Actually, an embedded system is where everything begins. This course provides the basics on embedded system, by focusing on the architectural patterns of modern systems and platforms. The embedded hardware and software aspects are addressed. This course also introduces connectivity and networking aspects, which are required to build distributed systems for the internet of things and the industrial internet of things (finally yielding Cyber-Physical Systems).

## Course Outcomes

On successful completion, students will be able to

- understand the architecture of embedded systems.
- understand real-time embedded systems.
- design the main architecture of embedded systems for robotics, automation and IoT infrastructure.

## Contents

1. Introduction
  - 1.1 Embedded Systems Overview
  - 1.2 Hardware Elements of an Embedded System
  - 1.3 Standards, Compilers and Programming Languages
2. Elements of a Microcontroller
  - 2.1 Central Processing Units
  - 2.2 Volatile and non-volatile memory
  - 2.3 Digital/Analog Input/Output
  - 2.4 Timing peripherals
  - 2.5 Communication peripherals

3. Programming a Microcontroller
  - 3.1 Bone Structure of a Microcontroller Software
  - 3.2 Low-Level Programming
  - 3.3 Usage of Middle-Level Libraries
  - 3.4 Common IDEs and Tools
4. Embedded Operating Systems
  - 4.1 Task Management
  - 4.2 Scheduler
  - 4.3 Examples of Embedded Operating Systems
5. Distributed Systems and IoT Architecture
  - 5.1 Network Interfaces
  - 5.2 The Internet Protocol
  - 5.3 Examples of Distributed Systems

## Literature

### Compulsory Reading

### Further Reading

- Barkalov, A./Titarenko, L./Mazurkiewicz, M. (2019): Foundations of Embedded Systems. In: Kacprzyk, J.: Studies in Systems, Decision and Control, Volume 195, Springer Nature, Chams.
- Lacamera, D. (2018): Embedded systems architecture: explore architectural concepts, pragmatic design patterns, and best practices to produce robust systems. Packt Publishing, Birmingham.
- Noergaard, T. (2013): Embedded Systems Architecture. Elsevier Inc, Amsterdam.
- Siegesmund, M. (2014): Embedded C Programming. Elsevier Inc, Amsterdam.
- Simon, D. E. (1999): An embedded software primer. Addison Wesley, Boston, MS.
- White, E. (2011): Making Embedded Systems. O'Reilly, Sebastopol, CL.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Programming with C/C++

Course Code: DLBROEPRS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

C and C++ belong to the class of programming languages which have been adopted in a broad field of applications, ranging from embedded systems (where they are dominant) to fast and reliable user interfaces and industrial applications. In fact, C++ is one of the most popular legacy programming languages for robotics, and a combination of C++ and robotics hardware is used in many leading industries. Knowledge on how to design in and write C/C++ code is an imperative capability for the practicing roboticist, especially in the industrial arena.

### Course Outcomes

On successful completion, students will be able to

- know the main characteristics of C and C++ programming languages.
- apply C and C++ for programming of applications.
- apply C and C++ for programming of robotic systems.

### Contents

- This course introduces the main aspects of C and C++ programming languages, such as data types, variables, arithmetic expressions, flow control, functions, classes, arrays, and pointers. The programming skills will then be applied to design parts of robotic systems based on popular hardware.

### Literature

#### Compulsory Reading

#### Further Reading

- Kernighan, B. W. & Ritchie, D. M. (2000). The C Programming Language, Second Edition. Pearson Education.
- Lippman, S. B., Lajoie, J., Moo, B. (2012). C++ Primer, Fifth Edition. Addison Wesley.
- Margolis, M. (2011). Arduino Cookbook. O'Reilly Media.
- Dogan, I. (2021). Nucleo Boards Programming with the STM32CubeIDE. Elektor.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Portfolio

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

DLBROEPRS01\_E

## Smart Services

Module Code: DLBINGSS\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Smart Services I) / N.N. (Smart Services II)

### Contributing Courses to Module

- Smart Services I (DLBINGSS01\_E)
- Smart Services II (DLBINGSS02\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Smart Services I

- Study Format "Distance Learning": Exam, 90 Minutes

##### Smart Services II

- Study Format "Distance Learning": Written Assessment: Project Report

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Smart Services I</b></p> <ul style="list-style-type: none"> <li>▪ Digitization and disruption</li> <li>▪ Potential of Smart Services</li> <li>▪ Development and specification of Smart Services</li> <li>▪ Service architectures</li> <li>▪ Integration platforms</li> <li>▪ Technologies for Smart Services</li> <li>▪ Quality and operation of Smart Services</li> </ul> <p><b>Smart Services II</b></p> <p>Analysis of a selected topic of Smart Services and design of a self-chosen assignment in a prototyping environment.</p>	
<p><b>Learning Outcomes</b></p> <p><b>Smart Services I</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ recognize the relevance of Smart Services in the context of digitization in general and Industry 4.0 in particular.</li> <li>▪ identify special features of digital business models and demonstrate them using the example of digital intermediaries.</li> <li>▪ apply methods to uncover digitization potentials and use the Business Model Canvas to classify them in a business model.</li> <li>▪ know and use models for the multi-perspective specification of services.</li> <li>▪ know selected architectures for the design and integration of services.</li> <li>▪ distinguish different technologies that are required for the development of services.</li> <li>▪ define the quality of services by means of Service Level Agreements.</li> </ul> <p><b>Smart Services II</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ have an in-depth understanding of the technologies and standards in the context of Smart Services.</li> <li>▪ apply technologies in the context of smart services using a simple practical example.</li> <li>▪ design a hardware or software prototype for a selected technical task.</li> <li>▪ document design and development activities in the form of a project report.</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>This module is similar to other modules in the fields of Computer Science &amp; Software Development</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All Bachelor Programs in the IT &amp; Technology fields</p>

## Smart Services I

Course Code: DLBINGSS01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

In this course, students study concepts and methods for the development of Smart Services. For this purpose, an introduction of the term in the context of digitization and Industry 4.0 will be given. Based on this, this course shows how innovative services can have a disruptive effect on existing business models or even markets using the example of digital intermediaries. Subsequently, students will be taught selected methods and techniques with which digitization potentials can be recognized and modelled. In addition, selected architectures and platforms for the integration of services are presented. Finally, relevant technologies for the implementation of smart services are taught and it is briefly described how the quality of services can be agreed upon.

### Course Outcomes

On successful completion, students will be able to

- recognize the relevance of Smart Services in the context of digitization in general and Industry 4.0 in particular.
- identify special features of digital business models and demonstrate them using the example of digital intermediaries.
- apply methods to uncover digitization potentials and use the Business Model Canvas to classify them in a business model.
- know and use models for the multi-perspective specification of services.
- know selected architectures for the design and integration of services.
- distinguish different technologies that are required for the development of services.
- define the quality of services by means of Service Level Agreements.

### Contents

1. Introduction and Motivation
  - 1.1 Digitization and Cyber-Physical Production Systems
  - 1.2 Smart Services in Industry 4.0
  - 1.3 Examples of Smart Services

2. Digitization and Disruption
  - 2.1 Definition: Digital Business Models
  - 2.2 Strategies for Change and Innovation
  - 2.3 Digital Intermediaries
  - 2.4 Examples of Disruptive Business Models
3. Recognizing Potential for Smart Services
  - 3.1 Business Model Canvas
  - 3.2 Personas
  - 3.3 Customer Journeys
  - 3.4 Domain-Driven Design
4. Development and Specification of Smart Services
  - 4.1 Modelling of the System Context
  - 4.2 Modelling of Business Processes
  - 4.3 Modelling of Technical Interfaces
  - 4.4 Tools for API Specification
5. Service Architectures
  - 5.1 Infrastructure/Platform/Software-as-a-Service
  - 5.2 Everything-as-a-Service
  - 5.3 Service-oriented Architectures
  - 5.4 Micro Services
6. Integration Platforms
  - 6.1 Features and Purpose of Integration Platforms
  - 6.2 Enterprise Integration Patterns
  - 6.3 External Integration with Zapier, IFTTT & Others
7. Technologies for Smart Services
  - 7.1 Formats for Data Exchange
  - 7.2 Internet Communication Protocols
  - 7.3 Semantic Descriptions
  - 7.4 Complex Event Processing
  - 7.5 Security

8. Quality and Operation of Smart Services
  - 8.1 Quality Characteristics and Maturity of APIs
  - 8.2 Service Level Agreements
  - 8.3 Service Level Management

## Literature

### Compulsory Reading

#### Further Reading

- Chignell, M. et al. (Hrsg.) (2010): The Smart Internet. Current Research and Future Applications. Springer, Berlin.
- Evans, E. (2003): Domain-Driven Design. Tackling Complexity in the Heart of Software. Addison-Wesley, Upper Saddle River, NJ.
- Hohpe, G./Woolf, B./Brown, K. (2012): Enterprise Integration Patterns. Designing, Building, and Deploying Messaging Solutions. 16th edition, Addison-Wesley, Boston, MA.
- Nielsen, L. (2013): Personas – User Focused Design. Springer, London.
- Osterwalder, A/Pigneur, Y. (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, John Wiley & Sons Inc., Hoboken, NJ.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides



## Smart Services II

Course Code: DLBINGSS02\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

In this course, the students select a concrete technical task from the provided topic catalogue in consultation with the seminar leader. They work on the task with the help of a prototyping environment that is suitable for the subject of the task. The environments can be hardware (e.g. prototyping boards) or software (e.g. technology-specific development environments). To complete the task, students apply the concepts, methods and tools taught in the Smart Services I course. They document their results in a project report.

### Course Outcomes

On successful completion, students will be able to

- have an in-depth understanding of the technologies and standards in the context of Smart Services.
- apply technologies in the context of smart services using a simple practical example.
- design a hardware or software prototype for a selected technical task.
- document design and development activities in the form of a project report.

### Contents

- A catalogue with currently available assignments is provided on the online learning platform. It provides the content basis of the module and can be supplemented or updated by the tutor.

### Literature

### Compulsory Reading

### Further Reading

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Project
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Project Report

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

## Renewable Energies

Module Code: DLBAETWEE\_E

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01_E	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

N.N. (Power Plant Technology) / N.N. (Regenerative Energy)

### Contributing Courses to Module

- Power Plant Technology (DLBAETWEE01\_E)
- Regenerative Energy (DLBAETWEE02\_E)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Power Plant Technology

- Study Format "Distance Learning": Exam, 90 Minutes

##### Regenerative Energy

- Study Format "Distance Learning": Exam, 90 Minutes

### Weight of Module

see curriculum

**Module Contents****Power Plant Technology**

- Introduction to Energy Conversion and Types of Energy Carriers
- Fundamentals of Thermodynamics
- Fossil-Fuel Power Station Processes and Network Layouts for Energy Transmission

**Regenerative Energy**

- Basic Terms of Renewable Energy
- Renewable Generation of Heat
- Renewable Energy Generation with Solar Power, Hydropower and Wind Power
- Utilization of Biomass and Waste
- Political Framework Conditions for Renewable Energies

**Learning Outcomes****Power Plant Technology**

On successful completion, students will be able to

- understand the basic power plant processes.
- understand thermodynamic fundamentals of power plant engineering.
- calculate efficiencies of processes.
- calculate processes for energy conversion.
- understand the network layout for energy transmission.

**Regenerative Energy**

On successful completion, students will be able to

- reproduce and understand the basic concepts of renewable energy.
- understand processes of geothermal and solar thermal energy.
- understand the function of heat pumps and design associated processes.
- understand processes for generating energy with wind power, hydropower, biomass and solar power.
- calculate energy generation with wind power, hydropower, biomass and solar power.

**Links to other Modules within the Study Program**

This module is similar to other modules in the field of Engineering

**Links to other Study Programs of the University**

All Bachelor Programs in the IT & Technology fields

# Power Plant Technology

Course Code: DLBAETWEE01\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01_E

## Course Description

The aim of the course is to give students an overview of interrelationships in power engineering. Different power plant processes for energy conversion are considered and analyzed how electrical energy can be generated by them and subsequently be transmitted through the electrical grid.

## Course Outcomes

On successful completion, students will be able to

- understand the basic power plant processes.
- understand thermodynamic fundamentals of power plant engineering.
- calculate efficiencies of processes.
- calculate processes for energy conversion.
- understand the network layout for energy transmission.

## Contents

1. Introduction to Energy Conversion
  - 1.1 Types of Energy
  - 1.2 Basic Terms of Power Plant Technology
  - 1.3 Thermal Energy and Electrical Energy
  - 1.4 Energy Conversion
  - 1.5 Energy Conversion Efficiency
2. Types of Energy Carriers
  - 2.1 Primary Energy Carriers
  - 2.2 Secondary Energy Carriers
  - 2.3 Fuels and their Properties

3. Fundamentals of Thermodynamics
  - 3.1 First Law of Thermodynamics
  - 3.2 Internal Energy, Heat and Thermodynamic Work
  - 3.3 Enthalpy
  - 3.4 Second Law of Thermodynamics
  - 3.5 Entropy
4. Thermodynamic Power Plant Processes
  - 4.1 Basics of Thermodynamic Cycles
  - 4.2 Heat Engines
  - 4.3 Changes of State Functions in Power Plant Processes
  - 4.4 Examples
5. Conventional Power Station Processes
  - 5.1 Chemical Transformations during Combustion
  - 5.2 Steam-Electric Power Stations
  - 5.3 Nuclear Fission and Fusion
  - 5.4 Thermal Energy Conversion Efficiency
6. Network Layout for Energy Transmission
  - 6.1 Conversion of Heat into Electrical Energy
  - 6.2 Conversion of Mechanical Energy into Electrical Energy
  - 6.3 Network Technology for AC and DC Powertrains
  - 6.4 Transmission of Electrical Energy
  - 6.5 Distribution of Electrical Energy

**Literature****Compulsory Reading****Further Reading**

- Elias P. Gyftopoulos, Gian Paolo Beretta. Thermodynamics : Foundations and Applications. Dover Publications; 2012. Accessed July 21, 2021
- Krischer, Katharina Schönleber, Konrad. (2015). Physics of Energy Conversion. De Gruyter
- Pawel Madejski. Thermal Power Plants - New Trends and Recent Developments. IntechOpen; 2018

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Regenerative Energy

Course Code: DLBAETWEE02\_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	either DLBAETLET01 and DLBAETEFW01 or DLBINGET01-01_E; DLBAETEME01_E

### Course Description

The aim of the course is to give students an overview of renewable energy technologies. The first topic is how heat can be generated with the help of geothermal energy and solar thermal energy. Furthermore, the basics of energy generation with wind power, hydropower and solar power are presented.

### Course Outcomes

On successful completion, students will be able to

- reproduce and understand the basic concepts of renewable energy.
- understand processes of geothermal and solar thermal energy.
- understand the function of heat pumps and design associated processes.
- understand processes for generating energy with wind power, hydropower, biomass and solar power.
- calculate energy generation with wind power, hydropower, biomass and solar power.

### Contents

1. Basic Terms of Renewable Energy
  - 1.1 Energy Return on Investment and Energy Payback Time
  - 1.2 Carbon Dioxide Amortization
  - 1.3 Energy Efficiency
2. Regenerative Generation of Heat
  - 2.1 Heat Pumps
  - 2.2 Thermodynamic Considerations of Heat Pumps
  - 2.3 Geothermal Energy
  - 2.4 Solar Thermal Energy
3. Renewable Energy Generation with Light Energy
  - 3.1 Functional Principle of Photovoltaics
  - 3.2 Use in the Power Grid



4. Renewable Energy Generation with Hydropower and Wind Power
  - 4.1 Hydroelectric Power Plants and Turbines
  - 4.2 Wind Turbines
  - 4.3 Location Factors for Wind Turbines and Hydropower Plants
5. Utilization of Biomass and Waste
  - 5.1 Biogas Plants
  - 5.2 Waste Incineration
  - 5.3 Examples
6. Political Framework Conditions for Renewable Energies
  - 6.1 EEG
  - 6.2 Legal Framework for New Wind Turbines
  - 6.3 Future Requirements for Energy Storage and Generation

**Literature****Compulsory Reading****Further Reading**

- Anani, Nader. (2020). Renewable Energy Technologies and Resources. Artech House.
- Krischer, Katharina Schönleber, Konrad. (2015). Physics of Energy Conversion. De Gruyter.
- Sallam, Abdelhay A. Malik, Om P. (2021). Power Grids with Renewable Energy - Storage, Integration and Digitalization. Institution of Engineering and Technology.

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Cryptography and IT-Law

Module Code: DLBENGECITL

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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## Module Coordinator

N.N. (Cryptography) / N.N. (IT Law)

## Contributing Courses to Module

- Cryptography (DLBCSCT01)
- IT Law (DLBCSIITL01)

## Module Exam Type

### Module Exam

### Split Exam

#### Cryptography

- Study Format "myStudies": Exam, 90 Minutes
- Study Format "Distance Learning": Exam, 90 Minutes

#### IT Law

- Study Format "Distance Learning": Written Assessment: Case Study
- Study Format "myStudies": Written Assessment: Case Study

## Weight of Module

see curriculum

**Module Contents****Cryptography**

- Protection Targets, Vulnerabilities, and Threats
- Foundations of Cryptology and its Core Components
- Basic Cryptographic Applications
- Authentication
- Single Computer Security
- Security Communication Network
- Security E-Commerce
- Secure Software Development

**IT Law**

- Basic Concepts of Legal Systems
- Internet and Domain Law
- Contracts
- Intellectual Property
- Data Protection / Privacy

**Learning Outcomes****Cryptography**

On successful completion, students will be able to

- give an overview of different classes of cryptographic systems.
- give a basic description of symmetric cryptographic methods, in particular One-Time Pad, DES, and AES, and describe their operating principles by means of simple, concrete examples.
- describe the basic hash functions.
- describe basic asymmetric cryptographic methods, especially RSA, and their operating principles by means of simple, concrete examples.
- describe the areas of application of cryptographic procedures and their application scenarios.

**IT Law**

On successful completion, students will be able to

- describe basic concepts of IT law.
- provide examples of different approaches to IT law in different countries.
- identify legal questions as they arise in IT.
- apply the core ideas of data protection and privacy in their work.
- distinguish the different types of contracts and intellectual property as they relate to IT.

**Links to other Modules within the Study Program**

This module is similar to other modules in the fields of Computer Science & Software Development

**Links to other Study Programs of the University**

All Bachelor Programmes in the IT & Technology fields

# Cryptography

Course Code: DLBCSCT01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

## Course Description

This course covers basic and targeted in-depth knowledge of cryptographic processes and the practical use of cryptographic systems. After an overview of cryptographic methods, hash functions, symmetric methods, and asymmetric methods are presented. The theoretical basics of selected procedures are taught and practically explained using simple examples. In addition, areas of application and application scenarios for cryptographic procedures are presented.

## Course Outcomes

On successful completion, students will be able to

- give an overview of different classes of cryptographic systems.
- give a basic description of symmetric cryptographic methods, in particular One-Time Pad, DES, and AES, and describe their operating principles by means of simple, concrete examples.
- describe the basic hash functions.
- describe basic asymmetric cryptographic methods, especially RSA, and their operating principles by means of simple, concrete examples.
- describe the areas of application of cryptographic procedures and their application scenarios.

## Contents

1. Protection Goals, Vulnerabilities, and Threats
  - 1.1 Protection Goals
  - 1.2 Vulnerabilities and Threats
2. Foundations of Cryptology and its Core Components
  - 2.1 Encoding
  - 2.2 Symmetrical Encryption
  - 2.3 Asymmetric Encryption
  - 2.4 One-way Functions and Cryptographic Hash Functions

3. Basic Cryptographic Applications
  - 3.1 Key exchange and Hybrid Processes
  - 3.2 Digital Signature
  - 3.3 Message Authentication Code
  - 3.4 Steganographic Methods
4. Authentication
  - 4.1 Passwords and Public-Key-Certificates
  - 4.2 Challenge-Response-Procedure and Zero-Knowledge-Procedure
  - 4.3 Biometric Methods
  - 4.4 Authentication in Distributed Systems
  - 4.5 Identities Through Smartcards
5. Security of Single Computers
  - 5.1 Malware and Cookies
  - 5.2 Some Special Features of Operating Systems
  - 5.3 Web Server Security
6. Security in Communication Networks
  - 6.1 Security Problems and Defense Concepts
  - 6.2 Internet Standards for Communication Security
  - 6.3 Identity and Anonymity
  - 6.4 Security in Mobile and Wireless Communications
7. Security in E-Commerce
  - 7.1 Email Security
  - 7.2 Online Banking and Online Payments
  - 7.3 Electronic Money
8. Secure Software Development
  - 8.1 Threat Modeling
  - 8.2 Secure Software Design
  - 8.3 Techniques for Safe Programming

**Literature**

**Compulsory Reading**

**Further Reading**

- Baumann, U./Franz, E./Pfitzmann, A. (2014): Kryptographische Systeme. Springer Vieweg, Wiesbaden.
- Beutelspacher, A. (2014): Kryptologie. Eine Einführung in die Wissenschaft vom Verschlüsseln, Verbergen und Verheimlichen. 10. Auflage, Springer Spektrum, Wiesbaden.
- Eckert, C. (2014): IT-Sicherheit. Konzepte – Verfahren – Protokolle. 9. Auflage, De Gruyter Oldenbourg, München.
- Ertel, W. (2010): Angewandte Kryptographie. 4. Auflage, Hanser, München.
- Spitz, S./Pramateftakis, M./Swoboda, J. (2011): Kryptographie und IT-Sicherheit. Grundlagen und Anwendungen. 2. Auflage, Vieweg+Teubner; Wiesbaden.



**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## IT Law

Course Code: DLBCSIITL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

The application of IT is embedded in a legal framework which computer scientists need to know and adhere to in their work. This applies to the way their own work is performed which, for example, may be governed by contracts with suppliers and/or customers. Computer scientists create and use intellectual property, and this leads to questions of copyright, software patents, etc. Beyond this, IT strongly influences the social environment and therefore needs to abide by regulations such as data protection. The goal of this module is to provide students with a basic understanding of these legal aspects so they can take them into account, apply them in simple cases, and recognize when more specialised legal knowledge is required. Since IT is a topic that connects different countries and legal frameworks, the course looks at some of the common legal questions as they are handled in the European Union, the USA, and India.

### Course Outcomes

On successful completion, students will be able to

- describe basic concepts of IT law.
- provide examples of different approaches to IT law in different countries.
- identify legal questions as they arise in IT.
- apply the core ideas of data protection and privacy in their work.
- distinguish the different types of contracts and intellectual property as they relate to IT.

### Contents

1. Basic Concepts of Legal Systems
  - 1.1 The Role of Law in IT
  - 1.2 Basic Concepts of the Legal System in the European Union
  - 1.3 Basic Concepts of the Legal System in the USA
  - 1.4 Basic Concepts of the Legal System in India
2. Internet and Domain Law
  - 2.1 Web Sites and the Law
  - 2.2 Net Neutrality
  - 2.3 Domain Registration
  - 2.4 Internet Crime

3. Contracts
  - 3.1 Types of IT Contracts
  - 3.2 Electronic Contracts and Electronic Signatures
  - 3.3 Licences
  - 3.4 Free and Open Source Software
  - 3.5 Buying and Selling Off-the-Shelf Software
  - 3.6 Software Development Contracts
4. Intellectual Property
  - 4.1 Brands, Trade Marks and Domain Names
  - 4.2 Copyright
  - 4.3 Software Patents
  - 4.4 Digital and Data Ownership
5. Data Protection/Privacy
  - 5.1 Basic Concepts of Data Protection
  - 5.2 Data Protection in the European Union: the GDPR
  - 5.3 Data Protection in the USA
  - 5.4 Data Protection in India
  - 5.5 Trans-Border Data Flows

#### Literature

#### Compulsory Reading

#### Further Reading

- Hoeren, T., & Pinelli, S. (2018). Agile programming – Introduction and current legal challenges. *Computer Law & Security Review*, 34(5), pp. 1131-1138. Retrieved from [www.uni-muenster.de/Jura.itm/hoeren/itm/wp-content/uploads/Hr.-Hoeren-29.10.pdf](http://www.uni-muenster.de/Jura.itm/hoeren/itm/wp-content/uploads/Hr.-Hoeren-29.10.pdf)
- Lloyd, I. (2018). *Information technology law* (8th ed.). Oxford: Oxford University Press.
- Murray, A. (2019). *Information technology law: The law and society* (4th ed.). Oxford: Oxford University Press.
- Soma, J. T. (2014). *Privacy law in a nutshell*. St. Paul, MN: West Academic.
- Wikia.org. (n.d.). The IT law wiki [web encyclopedia]. Retrieved from [https://itlaw.wikia.org/wiki/The\\_IT\\_Law\\_Wiki#](https://itlaw.wikia.org/wiki/The_IT_Law_Wiki#)

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Case Study
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Case Study

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Case Study
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Case Study

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Databases and Explorative Data Analysis and Visualization

Module Code: DLBENGEDEDAV

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	<ul style="list-style-type: none"> <li>▪ DLBDSIPWP01 or DLBDSIPWP01_D, DLBDSOOFPP01</li> <li>▪ none</li> </ul>	BA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
6. Semester	Minimum 1 semester	WiSe/SoSe	English

## Module Coordinator

Prof. Dr. Ralf Kneuper (Database Modeling and Database Systems) / Prof. Dr. Christian Müller-Kett (Explorative Data Analysis and Visualization)

## Contributing Courses to Module

- Database Modeling and Database Systems (DLBCSDMDS01)
- Explorative Data Analysis and Visualization (DLBDEDAV01)

## Module Exam Type

Module Exam	Split Exam
	<p><u>Database Modeling and Database Systems</u></p> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Exam, 90 Minutes</li> <li>• Study Format "Distance Learning": Exam, 90 Minutes</li> </ul> <p><u>Explorative Data Analysis and Visualization</u></p> <ul style="list-style-type: none"> <li>• Study Format "myStudies": Written Assessment: Written Assignment</li> <li>• Study Format "Distance Learning": Written Assessment: Written Assignment</li> </ul>

**Weight of Module**

see curriculum

**Module Contents**

**Database Modeling and Database Systems**

- Fundamentals of Relational Databases
- Simple Database Queries
- Entity/Relationship (E/R) Diagrams
- Database Development
- Complex Database Queries across Multiple Tables
- Changing Data in Databases
- NoSQL Database Systems

**Explorative Data Analysis and Visualization**

- Exploratory Data Analysis
- Principles of Data Visualization
- Established Visualization Types and Apposite Use Cases
- Commonly-Used Python Modules for Visualization
- Principles of Effective Visual Communication



### Learning Outcomes

#### Database Modeling and Database Systems

On successful completion, students will be able to

- describe the basic concepts of the relational data model and distinguish them from each other.
- visually model data schemas.
- know SQL queries, read data from databases, change the data stock, and have experience in their use.
- design, create, and modify SQL queries and data schemas for SQL databases, and have experience using them.
- independently design database schemas and create database queries to solve concrete problems.
- know the most important NoSQL concepts and distinguish them from each other.

#### Explorative Data Analysis and Visualization

On successful completion, students will be able to

- recognize foundational concepts of exploratory data analysis.
- cite principles of data visualization.
- identify well-established types of visualizations and their appropriate uses.
- describe visualization best practices.
- understand practical data visualization fundamentals in Python.
- use different approaches for effective visual communication of data science results.

#### Links to other Modules within the Study Program

This module is similar to other modules in the fields of Data Science & Artificial Intelligence

#### Links to other Study Programs of the University

All Bachelor Programmes in the IT & Technology field

## Database Modeling and Database Systems

Course Code: DLBCSDMDS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	none

### Course Description

Stored data form the basis of many value chains of an information and knowledge society. The methodical structuring of data through data schemas therefore forms an important basis for storing information in such a way that it can be retrieved and processed quickly and easily. In addition to the structured storage of data, structured access to large amounts of data must also be possible. This course teaches students how to store data in relational data models and how to access stored data with SQL. In addition to relational database systems, modern DB systems (NoSQL) for storing and accessing data will be presented.

### Course Outcomes

On successful completion, students will be able to

- describe the basic concepts of the relational data model and distinguish them from each other.
- visually model data schemas.
- know SQL queries, read data from databases, change the data stock, and have experience in their use.
- design, create, and modify SQL queries and data schemas for SQL databases, and have experience using them.
- independently design database schemas and create database queries to solve concrete problems.
- know the most important NoSQL concepts and distinguish them from each other.

### Contents

1. Fundamentals of Relational Databases
  - 1.1 Basic Concepts of the Relational Data Model
  - 1.2 Find and Delete Records in the Database
  - 1.3 SQL and Relational Database Systems

2. Querying Data from a Single Table
  - 2.1 Query Data (SELECT)
  - 2.2 Query Data With Condition (WHERE)
  - 2.3 Sort Query Output (ORDER BY)
  - 2.4 Queries With Group Formation (GROUP BY)
  - 2.5 Subqueries With Nested SELECT Statements
3. Conception and Modeling of Relational Databases
  - 3.1 The Entity Relationship Model
  - 3.2 Relationships and Cardinalities in E/R Models
  - 3.3 Normal Forms of Databases
4. Creation of Relational Databases
  - 4.1 Logical Database Design Activities
  - 4.2 Mapping of the Conceptual Data Model into the Physical Data Model
  - 4.3 Generation of Tables in SQL Databases from E/R Diagrams
5. Complex Database Queries on Multiple Tables
  - 5.1 Composite Quantities (JOIN)
  - 5.2 Set Operations
  - 5.3 Data Views With CREATE VIEW
6. Manipulating Records in Databases
  - 6.1 Insert New Data Records (INSERT)
  - 6.2 Change Existing Records
  - 6.3 Transactions
7. NoSQL Database Systems
  - 7.1 Motivation and Basic Idea
  - 7.2 Selected Groups of NoSQL Systems

**Literature****Compulsory Reading****Further Reading**

- 46th VLDB (2020). Proceedings of the International Conference on Very Large Data Bases (VLDB).
- Date, C.J. (2019). Database design and relational theory: Normal forms and all that jazz (2nd ed.). Apress.
- Documentation of Mondial Database (2010). Mondial Database.
- Elmasri, R., Navathe, S. B. (2016). Fundamentals of database systems. Pearson Education Limited.
- Foster, E., Godbole, S. (2016). Database systems. A pragmatic approach. (2nd ed.). Apress.
- Sumathi, S. et al (2010). Fundamentals of relational database management systems. Springer.
- W3Schools (2020). SQL Tutorial.

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Exam, 90 Minutes

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
90 h	0 h	30 h	30 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input checked="" type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

# Explorative Data Analysis and Visualization

Course Code: DLBDSSEDAV01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		5	DLBDSIPWP01 or DLBDSIPWP01_D, DLBDSOOFPP01

## Course Description

Obtaining an overview of the salient characteristics of a data set is one of the core activities at the outset of any data analysis endeavour. The corresponding activities, methods, and techniques are grouped under the term “exploratory data analysis”. During exploratory data analysis, gaining insight into a given data set is often aided by the application of suitable visualization techniques. The utility of visualization, however, does not end at this stage; it is also crucial for communicating analytical outcomes. This course first introduces a set of approaches, tools, and techniques that are useful for exploring data sets. It then takes a thorough look at the subject area of visualization, which is presented in detail by an exposition arc that spans from first principles of visualization to practical implementation to insights into the communication of data science results and findings.

## Course Outcomes

On successful completion, students will be able to

- recognize foundational concepts of exploratory data analysis.
- cite principles of data visualization.
- identify well-established types of visualizations and their appropriate uses.
- describe visualization best practices.
- understand practical data visualization fundamentals in Python.
- use different approaches for effective visual communication of data science results.

## Contents

1. Exploratory Data Analysis
  - 1.1 Location and variability
  - 1.2 Further exploration of data distribution
  - 1.3 Covariance and correlation
2. Data Visualization Principles
  - 2.1 Coordinates and axes
  - 2.2 Color spaces
  - 2.3 Graph types

3. Data Visualization Practice
  - 3.1 Amounts, proportions, associations, and distributions
  - 3.2 Time series and trends
  - 3.3 Geo-spatial data
4. Visualization in Python – Matplotlib and Seaborn
  - 4.1 Introduction to PyPlot, Matplotlib, and Seaborn
  - 4.2 Basic plots
  - 4.3 Geo-spatial plots
5. Communicating Data Science
  - 5.1 Unclutter, focus, and capture attention
  - 5.2 Lessons from design
  - 5.3 Principles of storytelling with data

**Literature****Compulsory Reading****Further Reading**

- Anderson, C. (2015). *Creating a data-driven organization*. Sebastopol, CA: O'Reilly Media.
- Bruce, A., & Bruce, P. (2017). *Practical statistics for data scientists*. Sebastopol, CA: O'Reilly Media.
- Grobmann, T., & Dobler, M. (2019). *Data visualization with Python*. Birmingham: Packt Publishing.
- Nussbaumer Knaflic, C. (2015). *Storytelling with data: A data visualization guide for business professionals*. Chichester: John Wiley & Sons.
- Wilke, C. O. (2019). *Fundamentals of data visualization*. Sebastopol, CA: O'Reilly Media.



**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Written Assignment

<b>Student Workload</b>					
<b>Self Study</b> 120 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 30 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 150 h

<b>Instructional Methods</b>		
<input type="checkbox"/> Learning Sprints®	<input type="checkbox"/> Review Book	<input type="checkbox"/> Sprint
<input checked="" type="checkbox"/> Course Book	<input type="checkbox"/> Creative Lab	<input type="checkbox"/> Interactive Online Lecture
<input type="checkbox"/> Vodcast	<input checked="" type="checkbox"/> Guideline	
<input checked="" type="checkbox"/> Shortcast	<input checked="" type="checkbox"/> Live Tutorium/Course Feed	
<input checked="" type="checkbox"/> Audio	<input type="checkbox"/> Reader	
<input type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Slides	

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Online Lecture
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> yes <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Written Assignment

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
110 h	0 h	20 h	20 h	0 h	150 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input checked="" type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input checked="" type="checkbox"/> Shortcast <input checked="" type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input checked="" type="checkbox"/> Guideline <input checked="" type="checkbox"/> Live Tutorium/Course Feed <input type="checkbox"/> Reader <input checked="" type="checkbox"/> Slides

## Bachelor Thesis

Module Code: DLBBT

<b>Module Type</b> see curriculum	<b>Admission Requirements</b> none	<b>Study Level</b> BA	<b>CP</b> 10	<b>Student Workload</b> 300 h
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<b>Semester / Term</b> 6. Semester	<b>Duration</b> Minimum 1 semester	<b>Regularly offered in</b> WiSe/SoSe	<b>Language of Instruction and Examination</b> English
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### Module Coordinator

Degree Program Advisor (SGL) (Bachelor Thesis) / Degree Program Advisor (SGL) (Colloquium)

### Contributing Courses to Module

- Bachelor Thesis (DLBBT01)
- Colloquium (DLBBT02)

### Module Exam Type

#### Module Exam

#### Split Exam

##### Bachelor Thesis

- Study Format "myStudies": Written Assessment: Bachelor Thesis
- Study Format "Distance Learning": Written Assessment: Bachelor Thesis

##### Colloquium

- Study Format "myStudies": Presentation: Colloquium
- Study Format "Distance Learning": Presentation: Colloquium

### Weight of Module

see curriculum

<p><b>Module Contents</b></p> <p><b>Bachelor Thesis</b></p> <ul style="list-style-type: none"> <li>▪ Bachelor's thesis</li> <li>▪ Colloquium on the bachelor's thesis</li> </ul> <p><b>Colloquium</b></p>	
<p><b>Learning Outcomes</b></p> <p><b>Bachelor Thesis</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ work on a problem from their major field of study by applying the specialist and methodological skills they have acquired during their studies.</li> <li>▪ independently analyze selected tasks with scientific methods, critically evaluate them, and develop appropriate solutions under the guidance of an academic supervisor.</li> <li>▪ record and analyze existing (research) literature appropriate to the topic of their bachelor's thesis.</li> <li>▪ prepare a detailed written elaboration in compliance with scientific methods.</li> </ul> <p><b>Colloquium</b></p> <p>On successful completion, students will be able to</p> <ul style="list-style-type: none"> <li>▪ present a problem from their field of study using academic presentation and communication techniques.</li> <li>▪ reflect on the scientific and methodological approach chosen in their bachelor's thesis.</li> <li>▪ demonstrate that they can actively answer subject-related questions from the subject experts (reviewers of the bachelor's thesis).</li> </ul>	
<p><b>Links to other Modules within the Study Program</b></p> <p>All modules in the bachelor program</p>	<p><b>Links to other Study Programs of the University</b></p> <p>All bachelor programs in distance learning</p>

## Bachelor Thesis

Course Code: DLBBT01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		9	none

### Course Description

The aim and purpose of the bachelor's thesis is to successfully apply the subject-specific and methodological competencies acquired during the course of study in the form of an academic dissertation with a thematic reference to the major field of study. The content of the bachelor's thesis can be a practical-empirical or theoretical-scientific problem. Students should prove that they can independently analyze a selected problem with scientific methods, critically evaluate it, and work out proposed solutions under the subject-methodological guidance of an academic supervisor. The topic chosen by the student from their respective field of study should meet the acquired scientific competences, deepening their academic knowledge and skills in order to meet the future needs of the field.

### Course Outcomes

On successful completion, students will be able to

- work on a problem from their major field of study by applying the specialist and methodological skills they have acquired during their studies.
- independently analyze selected tasks with scientific methods, critically evaluate them, and develop appropriate solutions under the guidance of an academic supervisor.
- record and analyze existing (research) literature appropriate to the topic of their bachelor's thesis.
- prepare a detailed written elaboration in compliance with scientific methods.

### Contents

- The bachelor's thesis must be written on a topic that relates to the content of the respective major field of study. In the context of the bachelor's thesis, the problem, as well as the scientific research goal, must be clearly emphasized. The work must reflect the current state of knowledge of the topic to be examined by means of an appropriate literature analysis. The student must prove their ability to use the acquired knowledge theoretically and/or empirically in the form of an independent and problem-solution-oriented application.

**Literature**

**Compulsory Reading**

**Further Reading**

- Turabian, K. L. (2013). A Manual for Writers of Research Papers, theses, and dissertations (8th ed.). University of Chicago Press.
- Lipson, C. (2018). How to write a BA thesis. A practical guide from your first ideas to your finished paper (2nd ed.). University of Chicago Press.
- Selection of literature according to topic

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Thesis
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Bachelor Thesis

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
270 h	0 h	0 h	0 h	0 h	270 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Thesis
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Written Assessment: Bachelor Thesis

<b>Student Workload</b>					
<b>Self Study</b> 270 h	<b>Contact Hours</b> 0 h	<b>Tutorial</b> 0 h	<b>Self Test</b> 0 h	<b>Independent Study</b> 0 h	<b>Hours Total</b> 270 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input checked="" type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides



## Colloquium

Course Code: DLBBT02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
BA	English		1	none

### Course Description

The colloquium will take place after the submission of the bachelor's thesis. This is done at the invitation of the experts. During the colloquium, students must prove that they have independently produced the content and results of the written work. The content of the colloquium is a presentation of the most important work contents and research results by the student as well as the answering of questions by experts.

### Course Outcomes

On successful completion, students will be able to

- present a problem from their field of study using academic presentation and communication techniques.
- reflect on the scientific and methodological approach chosen in their bachelor's thesis.
- demonstrate that they can actively answer subject-related questions from the subject experts (reviewers of the bachelor's thesis).

### Contents

- The colloquium includes a presentation of the most important results of the bachelor's thesis, followed by the student answering the reviewers' technical questions.

### Literature

#### Compulsory Reading

#### Further Reading

- Subject specific literature chosen by the student

**Study Format myStudies**

<b>Study Format</b> myStudies	<b>Course Type</b> Thesis Defense
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Presentation: Colloquium

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
30 h	0 h	0 h	0 h	0 h	30 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides

**Study Format Distance Learning**

<b>Study Format</b> Distance Learning	<b>Course Type</b> Thesis Defense
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<b>Information about the examination</b>	
<b>Examination Admission Requirements</b>	<b>BOLK:</b> no <b>Course Evaluation:</b> no
<b>Type of Exam</b>	Presentation: Colloquium

<b>Student Workload</b>					
<b>Self Study</b>	<b>Contact Hours</b>	<b>Tutorial</b>	<b>Self Test</b>	<b>Independent Study</b>	<b>Hours Total</b>
30 h	0 h	0 h	0 h	0 h	30 h

<b>Instructional Methods</b>	
<input type="checkbox"/> Learning Sprints® <input type="checkbox"/> Course Book <input type="checkbox"/> Vodcast <input type="checkbox"/> Shortcast <input type="checkbox"/> Audio <input type="checkbox"/> Exam Template	<input type="checkbox"/> Review Book <input type="checkbox"/> Creative Lab <input type="checkbox"/> Guideline <input type="checkbox"/> Live Tutorium/Course Feed <input checked="" type="checkbox"/> Slides