MODULE HANDBOOK

Master of Science

Computer Science in Cyber Security (FS-FI-MACSIS)

60 ECTS

Distance Learning

iu INTERNATIONAL UNIVERSITY OF APPLIED SCIENCES

Contents

2020-08-01

1. Semester

Algorithmics

Module Code: DLMCSA

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

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator
Prof. Dr. Paul Libbrecht (Algorithmics)

Contributing Courses to Module
▪ Algorithmics (DLMCSA01)

Module Exam Type	
Module Exam	**Split Exam**
Study Format: Distance Learning Exam, 90 Minutes	
Weight of Module see curriculum	

Module Contents
▪ Algorithm design ▪ Introduction to important classes of algorithms ▪ Correctness and completeness of algorithms ▪ Computability and the theoretical limits of algorithms ▪ Efficiency of algorithms

Learning Outcomes

Algorithmics

On successful completion, students will be able to

- explain the concept of algorithms and its relevance in computing.
- evaluate the correctness of software programs.
- discuss the theoretical and practical limits of software programs.
- select algorithms to solve specific application problems.
- design new algorithms based on standard methods to solve simple application problems.
- analyze and compare algorithms and outline their strengths and weaknesses.

Links to other Modules within the Study Program	Links to other Study Programs of IUBH
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

Algorithmics

Course Code: DLMCSA01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

A core activity of computer science and related disciplines is the design, use, and application of algorithms to solve problems. This course introduces common approaches to the design of algorithms, as well as important classes of algorithms that can be used to solve common problems. Performing these tasks successfully requires a thorough understanding of the quality characteristics of algorithms: (partial and total) correctness, accuracy, completeness, and efficiency. At the same time, there are limits to what an algorithm can and should achieve, in theory and in practice, and it is important to realize these limits and take them into account. Apart from algorithms based on standard programming paradigms, there are also various other programming paradigms that lead to other types of algorithms; therefore, this course also provides a short introduction to algorithms for parallel computing, probabilistic algorithms, and quantum algorithms.

Course Outcomes

On successful completion, students will be able to

- explain the concept of algorithms and its relevance in computing.
- evaluate the correctness of software programs.
- discuss the theoretical and practical limits of software programs.
- select algorithms to solve specific application problems.
- design new algorithms based on standard methods to solve simple application problems.
- analyze and compare algorithms and outline their strengths and weaknesses.

Contents

1. Introduction to Algorithms
    1.1 Basic Concepts and Historical Overview
    1.2 Algorithms, Programming Languages and Data Structures
    1.3 Quality Algorithms: Correctness, Accuracy, Completeness, Efficiency
    1.4 The Role of Algorithms in Society

2. Algorithm Design
    2.1 Data Structures
    2.2 Recursion and Iteration
    2.3 Divide-and-Conquer
    2.4 Balancing, Greedy Algorithms, and Dynamic Programming

3. Some Important Algorithms

    3.1   Sorting and Searching

    3.2   Pattern-Matching

    3.3   The RSA Algorithm

    3.4   The k-Means Algorithm for Data Clustering

4. Correctness, Accuracy, and Completeness of Algorithms

    4.1   Partial Correctness

    4.2   Total Correctness

    4.3   Ensuring Correctness in Day-to-Day Programming

    4.4   Accuracy, Approximation, and Error Analysis

5. Computability

    5.1   Models of Computation

    5.2   The Halting Problem

    5.3   Undecidable Problems

6. Efficiency of Algorithms: Complexity Theory

    6.1   Models of Complexity

    6.2   NP-Completeness

    6.3   P=NP?

7. Advanced Algorithmics

    7.1   Parallel Computing

    7.2   Probabilistic Algorithms

Literature
Compulsory Reading
Further Reading

- Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2013). Introduction to algorithms (3rd ed.). Cambridge, MA: MIT Press.
- Dewdney, A. K. (2001). The new turing omnibus. London: Macmillan Education.
- Harel, D. (2014). Algorithmics: The spirit of computing (3rd ed.). Berlin, Heidelberg: Springer.
- Sedgewick, A., & Wayne, K. (2011). Algorithms (4th ed.). Boston, MA: Pearson Education.
- Skiena, S. S. (2012). The algorithm design manual (2nd ed.). London: Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods
☐ Learning Sprints® ☐ Review Book   ☑ Course Book ☐ Creative Lab   ☐ Vodcast ☐ Guideline   ☑ Shortcast ☑ Live Tutorium/Course Feed   ☑ Audio   ☑ Exam Template

Cyber Security and Data Protection
Module Code: DLMCSITSDP

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

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator
Prof. Dr. Ralf Kneuper (Cyber Security and Data Protection)

Contributing Courses to Module
▪ Cyber Security and Data Protection (DLMCSITSDP01)

Module Exam Type	
Module Exam	**Split Exam**
Study Format: Distance Learning Oral Assignment	
Weight of Module see curriculum	

Module Contents
▪ Data protection and privacy ▪ Cyber security building blocks ▪ Cyber security management ▪ Cryptography concepts ▪ Cryptography applications

Learning Outcomes

Cyber Security and Data Protection

On successful completion, students will be able to

- explain the core concepts of cyber security, data protection, and cryptography including their differences and relationships.
- compare the approaches to data protection within in different legal systems.
- apply data protection concepts to data science and other application scenarios.
- analyze application scenarios to identify the adequate cyber security management measures that should be implemented.

Links to other Modules within the Study Program	Links to other Study Programs of IUBH
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

Cyber Security and Data Protection

Course Code: DLMCSITSDP01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

With the increasing digitization and networking of IT systems, the need for safeguarding systems and the data processed by these systems has grown. The aim of this module is to provide an understanding of security measures needed, cyber security including cryptography, and data protection. While the need for cyber security is similar around the world, different cultures have different expectations regarding data protection and privacy. Nevertheless, personal data are often processed outside the country where the affected individuals live. Hence, the cultural aspects of data protection need to be taken into account wherever the data are processed. This course provides an overview of the main cyber security measures in different application scenarios, as well as their integration into an Information Security Management System, with particular focus on the relevant ISO/IEC 270xx family of standards. Cryptography provides an important tool set for cyber security and is used in many different application scenarios such as secure Internet protocols and block chain.

Course Outcomes

On successful completion, students will be able to

- explain the core concepts of cyber security, data protection, and cryptography including their differences and relationships.
- compare the approaches to data protection within in different legal systems.
- apply data protection concepts to data science and other application scenarios.
- analyze application scenarios to identify the adequate cyber security management measures that should be implemented.

Contents

1. Foundations of Data Protection and Cyber Security
    1.1 Terminology and Risk Management
    1.2 Core Concepts of Cyber Security
    1.3 Core Concepts of Data Protection and Privacy
    1.4 Core Concepts of Cryptography
    1.5 Legal Aspects

2. Data Protection

    2.1   Basic Concepts of Data Protection (ISO/IEC 29100, Privacy by Design)

    2.2   Data Protection in Europe: the GDPR

    2.3   Data Protection in the USA

    2.4   Data Protection in Asia

3. Applying Data Protection

    3.1   Anonymity and Pseudonyms (k-Anonymity, i-Diversity, Differential Privacy)

    3.2   Data Protection in Data Science and Big Data

    3.3   User Tracking in Online Marketing

    3.4   Cloud Computing

4. Building Blocks of Cyber Security

    4.1   Authentication, Access Management and Control

    4.2   Cyber Security in Networks

    4.3   Developing Secure IT Systems (OWASP, etc.)

5. Cyber Security Management

    5.1   Security Policy

    5.2   Security and Risk Analysis

    5.3   The ISO 270xx Series

    5.4   IT Security and IT Governance

    5.5   Example: Cyber Security for Credit Cards (PCI DSS)

6. Cryptography

    6.1   Symmetric Cryptography

    6.2   Asymmetric Cryptography

    6.3   Hash Functions

    6.4   Secure Data Exchange (Diffie-Hellman, Perfect Forward Secrecy, etc.)

7. Cryptographic Applications

    7.1   Digital Signatures

    7.2   Electronic Money

    7.3   Secure Internet Protocols (TLS, IPSec, etc.)

    7.4   Block Chain

Literature
Compulsory Reading
Further Reading

- Walker, B. (2019). Cyber security comprehensive beginners guide to learn the basics and effective methods of cyber security. Independently published.
- Amoroso, E., & Amoroso, M. (2017). From CIA to APT: An introduction to cyber security. Independently published.
- National Institute of Standards and Technology. (2018). Framework for improving critical infrastructure cybersecurity.
- Paar, C., Pelzl, J. (2011). Understanding cryptography: A textbook for students and practitioners. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study 110 h	**Presence** 0 h	**Tutorial** 20 h	**Self Test** 20 h	**Practical Experience** 0 h	**Hours Total** 150 h

Instructional Methods

☐ Learning Sprints®
☑ Course Book
☐ Vodcast
☑ Shortcast
☑ Audio
☐ Exam Template

☐ Review Book
☐ Creative Lab
☑ Guideline
☑ Live Tutorium/Course Feed

Seminar: Advanced Cyber Security
Module Code: DLMCSSAITS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMCSITSDP01, DLMDSAM01	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator
Prof. Dr. Alexander Lawall (Seminar: Advanced Cyber Security)

Contributing Courses to Module
▪ Seminar: Advanced Cyber Security (DLMCSEAITSC01)

Module Exam Type	
Module Exam	**Split Exam**
Study Format: Distance Learning Written Assessment: Research Essay	
Weight of Module	
see curriculum	

Module Contents
▪ This course covers selected advanced topics in cyber security, including the closely related topics of data protection and cryptology, and discusses them in detail. Based on a list of topics updated regularly, students select or are assigned a specific topic about which they write a scientific research essay.

Learning Outcomes

Seminar: Advanced Cyber Security

On successful completion, students will be able to

- analyze and describe one aspect of cyber security in detail.
- independently analyze selected topics in cyber security and link them with well-known concepts, as well as critically question and discuss them.
- transfer theoretically-acquired knowledge to a specific context.
- write and edit a scientific essay on a relevant select topic.

Links to other Modules within the Study Program	Links to other Study Programs of IUBH
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

Seminar: Advanced Cyber Security

Course Code: DLMCSEAITSC01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	DLMCSITSDP01 or DLMCSITSDS01

Course Description

This seminar covers advanced topics in cyber security. With the growth of the internet and digitization, cyber security has become an increasingly important topic and needs to be taken into account in the development and setup of software and IT systems. Typical topics that may be addressed include the analysis of selected aspects of information security management systems according to the ISO 27000 series; the use of cyber security to support data protection; and the detailed analysis and description of certain algorithms or cryptosystems.

Course Outcomes

On successful completion, students will be able to

- analyze and describe one aspect of cyber security in detail.
- independently analyze selected topics in cyber security and link them with well-known concepts, as well as critically question and discuss them.
- transfer theoretically-acquired knowledge to a specific context.
- write and edit a scientific essay on a relevant select topic.

Contents

- The seminar covers different advanced topics regarding cyber security. Each participant must prepare a research essay on a topic assigned to him/her.

Literature
Compulsory Reading
Further Reading
- Turabian, K. L. (2013). A manual for writers of research papers, theses, and dissertations. Chicago: University of Chicago Press.   - Swales, J. M., & Feak, C. R. (2012). Academic writing for graduate students, essential tasks and skills. Michigan: University of Michigan Press.   - Bailey, S. (2011). Academic writing for international students of business. New York, NY: Routledge.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study 120 h	**Presence** 0 h	**Tutorial** 30 h	**Self Test** 0 h	**Practical Experience** 0 h	**Hours Total** 150 h

Instructional Methods
☐ Learning Sprints®   ☐ Review Book ☐ Course Book   ☐ Creative Lab ☐ Vodcast   ☑ Guideline ☐ Shortcast   ☑ Live Tutorium/Course Feed ☐ Audio ☐ Exam Template

Cryptology

Module Code: DLMCSC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMCSEAITSC01; DLMCSITSDP01 or DLMCSITSDS01	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator
Prof. Dr. Ralf Kneuper (Cryptology)

Contributing Courses to Module
▪ Cryptology (DLMCSEAITSC02)

Module Exam Type	
Module Exam	**Split Exam**
Study Format: Distance Learning Oral Assignment	
Weight of Module	
see curriculum	

Module Contents
▪ Symmetric and asymmetric cryptosystems ▪ Authentication ▪ Cryptanalysis ▪ Cryptology in the internet ▪ Applications

Learning Outcomes

Cryptology

On successful completion, students will be able to

- discuss the main cryptographic systems and algorithms and their relevance in IT today.
- discuss the security of internet-based applications.
- evaluate different cryptographic systems and algorithms to select an appropriate solution for real-world problems in IT.
- apply standard cryptographic systems and algorithms to solve real-world problems in IT.
- appraise existing cryptographic solutions to real-world problems and identify major weaknesses where relevant.

Links to other Modules within the Study Program	Links to other Study Programs of IUBH
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

Cryptology

Course Code: DLMCSEAITSC02

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	DLMCSEAITSC01; DLMCSITSDP01 or DLMCSITSDS01

Course Description

The focus of this course is to provide a thorough introduction to cryptology and its main sub-disciplines cryptography and cryptanalysis. Particular emphasis is put on the use of cryptology to support the security of IT systems. In the first part of the courses, students gain a solid understanding of the basic concepts of cryptology, in particular symmetric and asymmetric cryptosystems, authentication, and common approaches to break these cryptosystems using cryptanalysis. Based on this foundational understanding, the course goes on to cover the practical use of cryptology, starting with an introduction to the standard protocols and techniques used to ensure the security of communication via the internet. Next, practical aspects of applying cryptographic techniques and algorithms are covered, such as their long-term security. Finally, some application examples show how the concepts of cryptology are commonly used and can be used to solve challenges such as online banking.

Course Outcomes

On successful completion, students will be able to

- discuss the main cryptographic systems and algorithms and their relevance in IT today.
- discuss the security of internet-based applications.
- evaluate different cryptographic systems and algorithms to select an appropriate solution for real-world problems in IT.
- apply standard cryptographic systems and algorithms to solve real-world problems in IT.
- appraise existing cryptographic solutions to real-world problems and identify major weaknesses where relevant.

Contents

1. Basic concepts of cryptology
    1.1 Introduction and terminology
    1.2 IT security, threats and common attacks
    1.3 Historical overview
    1.4 Kerckhoffs's principle

2. Symmetric cryptosystems

    2.1 Substitution and transposition

    2.2 Stream and block ciphers

    2.3 Digital encryption standard (DES)

    2.4 Advanced encryption standard (AES)

3. Asymmetric cryptosystems

    3.1 The RSA algorithm

    3.2 Elliptic curves

    3.3 Cryptographic hash functions

    3.4 Signatures and MACs

    3.5 Key exchange and public key infrastructures

4. Authentication

    4.1 Passwords

    4.2 Challenge-response and zero-knowledge

    4.3 Biometrics-based authentication

    4.4 Authentication in distributed systems

    4.5 Smartcards

    4.6 Identity and anonymity

5. Cryptanalysis – how to break encryption

    5.1 Frequency analysis

    5.2 Brute-force attacks

    5.3 Rainbow tables

    5.4 Known/chosen plaintext

    5.5 Side-channel attacks

6. Cryptology and the internet

    6.1 Basic setup of the Internet and its protocols

    6.2 IPSec

    6.3 Transport Layer Security

    6.4 Secure E-Mail (TLS, S/MIME and PGP)

    6.5 Secure DNS

7. Practical aspects of cryptology

    7.1 Random number generation

    7.2 Long-term security (key lengths, perfect forward security, quantum computing)

    7.3 Incorporating cryptography into application development

    7.4 Legal and regulatory aspects

8. Applications

    8.1 Online banking

    8.2 Blockchain

    8.3 Voting

    8.4 Steganography and watermarks

    8.5 The Tor Project

Literature
Compulsory Reading
Further Reading

- Esslinger, B. (2010). The CrypTool script: Cryptography, mathematics, and more (10th ed.). CrypTool Development Team.
- Katz, J., & Lindell, Y. (2014). Introduction to modern cryptography (2nd ed.). Chapman and Hall/CRC.
- Menezes, A. J., van Oorschot, P. C., & Vanstone, S. A. (2015). Handbook of applied cryptography. CRC Press.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study 110 h	**Presence** 0 h	**Tutorial** 20 h	**Self Test** 20 h	**Practical Experience** 0 h	**Hours Total** 150 h

Instructional Methods	
☐ Learning Sprints® ☑ Course Book ☐ Vodcast ☑ Shortcast ☑ Audio ☐ Exam Template	☐ Review Book ☐ Creative Lab ☑ Guideline ☑ Live Tutorium/Course Feed

Blockchain

Module Code: DLMCSBC

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

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Rald Kneuper (Blockchain)

Contributing Courses to Module

- Blockchain (DLMCSEBCQC01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Written Assessment: Written Assignment	
Weight of Module see curriculum	

Module Contents

- Basic concepts of blockchain and related technologies
- Applications of blockchain and DLT
- Security
- Development of blockchain and DLT applications
- Social and legal aspects

Learning Outcomes	
Blockchain	
On successful completion, students will be able to	
▪ outline the functions provided by and the technology used in blockchains. ▪ explain important applications of block chains, in particular BitCoin. ▪ demonstrate the technical architecture of blockchain applications. ▪ appraise the benefits and challenges of suggested blockchain applications. ▪ discuss the social and legal aspects of blockchain technology.	
Links to other Modules within the Study Program	**Links to other Study Programs of IUBH**
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

Blockchain

Course Code: DLMCSEBCQC01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	None

Course Description

Started by the cryptocurrency BitCoin, blockchain and related topics such as distributed ledger technologies and smart contracts have become increasingly important over the last few years and are claimed to be a major disruptive technologies. As BitCoin shows, systems that today need a trustworthy central coordinating body may become genuinely distributed systems without the need for such a body in the future. While blockchain has the potential for completely new types of applications, these suggested applications do not always make use of the strengths of the technology; rather, they simply provide a different approach to solving problems that could be solved more easily and efficiently using standard technologies such as database systems. Furthermore, blockchain applications have led to new social challenges and legal questions, such as the legal status of "smart contracts". Different infrastructures such as Ethereum and Hyperledger have been developed to form the basis for blockchain applications. The goal of this course is to provide an understanding of the technical, as well as social and legal, aspects of blockchain and related technologies.

Course Outcomes

On successful completion, students will be able to

- outline the functions provided by and the technology used in blockchains.
- explain important applications of block chains, in particular BitCoin.
- demonstrate the technical architecture of blockchain applications.
- appraise the benefits and challenges of suggested blockchain applications.
- discuss the social and legal aspects of blockchain technology.

Contents

1. Basic Concepts
    1.1   The Functional View: Distributed Ledger Technologies
    1.2   The Technical View: Blockchain
    1.3   History of Blockchain and DLT
    1.4   Consense Mechanisms

2.   BitCoin

    2.1   The BitCoin Payment System

    2.2   The Technology Behind BitCoin

    2.3   Security of BitCoin

    2.4   Scalability and Other Limitations of BitCoin

    2.5   BitCoin Derivatives and Alternatives

3.   Smart Contracts and Decentralized Apps

    3.1   Smart Contracts

    3.2   Decentralized Apps (DApps)

    3.3   Ethereum

    3.4   Hyperledger

    3.5   Alternative Platforms for Smart Contracts and DApps

4.   Security of Block Chain and DLT

    4.1   Cryptology Used

    4.2   Attacks on Blockchain and DLT

    4.3   Resolving Bugs and Security Holes

    4.4   Long-Term Security

5.   Block Chain and DLT Application Scenarios

    5.1   Benefits and Limits of Applying Blockchain and DLT

    5.2   Registers for Land and Other Property

    5.3   Applications in the Supply Chain

    5.4   Applications in Insurance

    5.5   Initial Coin Offerings for Sourcing Capital

    5.6   Examples of Further Applications

6.   Development of Blockchain and DLT Applications

    6.1   Architecture of Blockchain and DLT Applications

    6.2   Platform Selection

    6.3   Design of Blockchain and DLT Applications

7.   Blockchain and Society

    7.1   (Mis-)Trust in Institutions

    7.2   Blockchain and the Environment

    7.3   Cyber-Currencies in the Darknet

    7.4   ICO Fraud

8. Legal Aspects

    8.1   DLT and Smart Contracts as Legal Contracts

    8.2   Cryptocurrencies as Legal Currencies

    8.3   Regulation of ICOs

    8.4   Data Protection / Privacy in Blockchains

Literature
Compulsory Reading
Further Reading

- De Filippi, P., & Wright, A. (2018). Blockchain and the law. The rule of code. Cambridge, MA: Harvard University Press.
- Meinel, C., Gayvoronskaya, T. & Schnjakin, M. (2018). Blockchain. Hype or innovation. Potsdam: Universitätsverlag Potsdam.
- Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system [white paper]. Retrieved from https://bitcoin.org/bitcoin.pdf
- Tapscott, D., & Tapscott, N. (2018). Blockchain revolution. How the technology behind bitcoin is changing money, business, and the world. New York, NY: Portfolio/Penguin.
- Xu, W., Weber, I., & Staples, M. (2019). Architecture for blockchain applications. Cham: Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study 110 h	**Presence** 0 h	**Tutorial** 20 h	**Self Test** 20 h	**Practical Experience** 0 h	**Hours Total** 150 h

Instructional Methods

☐ Learning Sprints®
☑ Course Book
☐ Vodcast
☑ Shortcast
☑ Audio
☐ Exam Template

☐ Review Book
☐ Creative Lab
☑ Guideline
☑ Live Tutorium/Course Feed

Seminar: Computer Science and Society
Module Code: DLMCSSCSAS

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

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. André Köhler (Seminar: Computer Science and Society)

Contributing Courses to Module

- Seminar: Computer Science and Society (DLMCSSCSAS01)

Module Exam Type	
Module Exam	**Split Exam**
Study Format: Fernstudium Written Assessment: Research Essay	
Weight of Module see curriculum	

Module Contents

- The seminar covers the relationship between computer science and society, including topics such as the social responsibility of computer scientists and the effects of digitization on society. Based on a list of topics updated regularly, students select or are assigned a specific topic on which to write a scientific report.

Learning Outcomes

Seminar: Computer Science and Society

On successful completion, students will be able to

- name the main questions regarding the relationship between computer science and society.
- discuss selected topics regarding the relationship between computer science and society.
- analyze one aspect of the relationship between computer science and society in detail.
- take selected topics and case studies and link them with well-known concepts, as well as critically question and discuss them.
- transfer theoretically acquired knowledge to a specific context.
- edit scientifically a select topic.

Links to other Modules within the Study Program	Links to other Study Programs of IUBH
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

Seminar: Computer Science and Society

Course Code: DLMCSSCSAS01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	None

Course Description

The seminar covers the relationship between computer science and society. Over the past several decades, computer science has greatly changed society, and it is important that prospective computer scientists think about the effects of computer science on society and take these influences into account in their work. Typical topics to be addressed include, for example, the effects of ethics and professionalism in computing, the responsibility of computer scientists, the effects of data science and social networks on society, surveillance, and dual use of IT.

Course Outcomes

On successful completion, students will be able to

- name the main questions regarding the relationship between computer science and society.
- discuss selected topics regarding the relationship between computer science and society.
- analyze one aspect of the relationship between computer science and society in detail.
- take selected topics and case studies and link them with well-known concepts, as well as critically question and discuss them.
- transfer theoretically acquired knowledge to a specific context.
- edit scientifically a select topic.

Contents

- The seminar covers different topics regarding the relationship between computer science and society. Each participant must create a seminar paper on a topic assigned to him/her and present the contents of the written paper.

Literature
Compulsory Reading
Further Reading
- Turabian, K. L. (2013). A manual for writers of research papers, theses, and dissertations. Chicago: University of Chicago Press.   - Swales, J. M., & Feak, C. R. (2012). Academic writing for graduate students, essential tasks and skills. Michigan: University of Michigan Press.   - Bailey, S. (2011). Academic writing for international students of business. New York, NY: Routledge

Study Format Fernstudium

Study Format	Course Type
Fernstudium	Seminar

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods
☐ Learning Sprints®   ☐ Review Book   ☐ Course Book   ☐ Creative Lab   ☐ Vodcast   ☑ Guideline   ☐ Shortcast   ☐ Live Tutorium/Course Feed   ☐ Audio   ☐ Exam Template

2. Semester

Quantum Computing

Module Code: DLMCSQC

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

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Dr. Carsten Blank (Quantum Computing)

Contributing Courses to Module

- Quantum Computing (DLMCSEBCQC02)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Oral Assignment	
Weight of Module see curriculum	

Module Contents

- Physics of quantum computing
- Quantum computing models
- Quantum algorithms
- Quantum computing with the IBM framework Qiskit
- Applications, potential for and challenges of quantum computing

Learning Outcomes

Quantum Computing

On successful completion, students will be able to

- outline the basic concepts of quantum mechanics as they relate to quantum computing.
- describe the computation models used in quantum computing.
- demonstrate the role of quantum computing for cryptography and other application areas.
- compare the theoretical and practical potential of quantum computing to classical computing.
- apply the concepts of quantum computing to develop simple programs within the Qiskit framework.

Links to other Modules within the Study Program	**Links to other Study Programs of IUBH**
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

Quantum Computing

Course Code: DLMCSEBCQC02

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

Quantum computing is a completely new paradigm for the architecture of computers. It currently is in the early stage of development but has the potential to speed up certain kinds of computations, not just by orders of magnitude but by moving them from exponential to linear growth. One of the issues that will be affected is the prime factorization of large numbers which currently forms the basis for important cryptographic algorithms, in particular the RSA algorithm which would in that case would no longer be secure. This course gives an introduction to the physics behind quantum computing and the computation models used. Students are familiarized with the most important algorithms for quantum computing and write a few programs for quantum computers. The application potential and challenges of quantum computing are also discussed.

Course Outcomes

On successful completion, students will be able to

- outline the basic concepts of quantum mechanics as they relate to quantum computing.
- describe the computation models used in quantum computing.
- demonstrate the role of quantum computing for cryptography and other application areas.
- compare the theoretical and practical potential of quantum computing to classical computing.
- apply the concepts of quantum computing to develop simple programs within the Qiskit framework.

Contents

1. Basic concepts
    1.1 Quantum physics as a basis for computing
    1.2 Types of quantum computers
    1.3 Qbits
    1.4 Linear algebra

2. The physics of quantum computers

   2.1 Basic concepts of quantum mechanics

   2.2 Spin and entanglement

   2.3 Architecture of quantum computers

   2.4 Noise and error correction

   2.5 Current state and outlook

3. Quantum computing models

   3.1 Quantum gates and circuits

   3.2 Single qubit quantum systems

   3.3 Multiple qubit quantum systems

4. Quantum algorithms

   4.1 Computability and complexity in quantum computing

   4.2 Quantum Fourier transform

   4.3 The Shor algorithm

   4.4 The Grover algorithm

5. Quantum computing with the IBM framework Qiskit

   5.1 Overview of Qiskit and the IBM Q Provider

   5.2 Quantum circuits in Qiskit

   5.3 First steps in programming with Qiskit

6. Applications, potential and challenges of quantum computing

   6.1 Applications of quantum computing

   6.2 Quantum cryptography and post-quantum cryptography

   6.3 Quantum supremacy

Literature
Compulsory Reading
Further Reading

- Mermin, N. D. (2007). Quantum computer science: An introduction. Cambridge University Press.
- Nielsen, M. A., & Chuang, I. L. (2000). Quantum computation and quantum information. Cambridge University Press.
- Rieffel, E. G., & Polak, W. H. (2011). Quantum computing: A gentle introduction. MIT Press.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study 110 h	**Presence** 0 h	**Tutorial** 20 h	**Self Test** 20 h	**Practical Experience** 0 h	**Hours Total** 150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	
☐ Exam Template	

DLMCSEBCQC02

IT Project Management
Module Code: DLMCSITPM

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

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Inga Schlömer (IT Project Management)

Contributing Courses to Module

- IT Project Management (DLMBITPAM01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Exam	
Weight of Module see curriculum	

Module Contents

- Organizing the work
- Cost estimation and controlling
- The human factor
- Organizing small and medium projects
- Organizing large projects

Learning Outcomes

IT Project Management

On successful completion, students will be able to

- critically reflect the status of knowledge on IT project management.
- set up different IT project management formats (small, medium and large projects) and know the methods for managing these different IT projects professionally.
- develop an IT management proposal as the fundament of a professional IT project management concept.
- understand and integrate different IT management project plans (e.g., time plan, cost plan, resources plan, risk plan) and use those plans in an integrative IT project planning and controlling scheme.
- organize and to lead an IT project team and its core and/or extended team members.

Links to other Modules within the Study Program	**Links to other Study Programs of IUBH**
This module is similar to other modules in the field of Computer Science & Software Development.	All Master Programmes in the IT & Technology field.

IT Project Management

Course Code: DLMBITPAM01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

The purpose of this course is to introduce students to the concepts involved in IT project management. This is achieved through the development of an understanding of the fundamental tenets of project management enhancing the students' ability to apply their knowledge, skills and competencies in analyzing and solving IT project management problems. A special focus is put on the specifics of IT project organization, cost management and the human factor within IT projects.

Course Outcomes

On successful completion, students will be able to

- critically reflect the status of knowledge on IT project management.
- set up different IT project management formats (small, medium and large projects) and know the methods for managing these different IT projects professionally.
- develop an IT management proposal as the fundament of a professional IT project management concept.
- understand and integrate different IT management project plans (e.g., time plan, cost plan, resources plan, risk plan) and use those plans in an integrative IT project planning and controlling scheme.
- organize and to lead an IT project team and its core and/or extended team members.

Contents

1. Introduction: Characteristics of IT Projects
    1.1 Defining IT Projects
    1.2 Overview on Typical Roles and Phases of IT Projects
    1.3 Risks and Challenges of IT Projects
    1.4 Role of an IT Project Manager

2. Organizing the Work
    2.1 Project Breakdown Structure, Work Packages
    2.2 Prioritization
    2.3 Time Planning, Milestones, Gantt-Diagram
    2.4 Definition of Done

3. Cost Estimation and Controlling

    3.1 Challenges of Cost Estimation in IT Projects

    3.2 Estimation Techniques: 3-Point Estimation, Double Blind Expert Estimation, Function Points

    3.3 Cost Controlling Using Earned Value Analysis

    3.4 Risk Management

4. The Human Factor

    4.1 Vision Keeping

    4.2 Stakeholder Management

    4.3 Conflict Management

5. Organizing Small and Medium Projects

    5.1 Rational Unified Process (RUP)

    5.2 Agile Software Processes

    5.3 Scrum

    5.4 Plan-driven Project Management in Small Projects

6. Organizing Large Projects

    6.1 PMBOK Guide

    6.2 Prince2

    6.3 Multi Project Management

    6.4 Agile Software Processes in Large Projects

    6.5 Selection of the Appropriate Project Management Method

Literature
Compulsory Reading
Further Reading

- Stephens, R. (2015). Beginning software engineering. Chichester: John Wiley & Sons. (Database: ProQuest).
- Hans, R. T. (2013). Work breakdown structure: A tool for software project scope verification. Pretoria: Tshwane University of Technology.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	
☑ Exam Template	

Master Thesis

Module Code: DLMMTHE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	See study and exam regulation (SPO).	MA	20	600 h

Semester / Term	Duration	Regularly offered in	Language of Instruction
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator
Degree Program Advisor (SGL) (Master Thesis) / N.N. (Thesis Defence)

Contributing Courses to Module
▪ Master Thesis (DLMMTHE01) ▪ Thesis Defence (DLMMTHE02)

Module Exam Type	
Module Exam	**Split Exam** Master Thesis • Study Format "Distance Learning": Written Assessment: Master Thesis Thesis Defence • Study Format "Distance Learning": Presentation: Colloquium
Weight of Module see curriculum	

Module Contents
Master Thesis
▪ Written Master Thesis
Thesis Defense
Thesis Defence

Learning Outcomes
Master Thesis
On successful completion, students will be able to
▪ The objective of this module is the completion of a written assignment, in line with scientific methodology, that demonstrates the student's capabilities through independent investigation of a topic pertaining to the master program's area of focus.
Thesis Defence
On successful completion, students will be able to
▪ The main objective of the thesis defense is for the student to prove their competence in research methodology and the specific subject matter. The students should also be able to actively participate in a subject specific discussion at a higher academic level with subject area experts. Additionally, the defense will evaluate the academic presentation skills and overall communication skills of the student.

Links to other Modules within the Study Program	Links to other Study Programs of IUBH
This module is similar to other modules in the field of Methods.	All Master Programmes in the Business & Administration field.

Master Thesis

Course Code: DLMMTHE01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		18	See current study and exam regulations (SPO)

Course Description

The aim of the master thesis is to effectively apply the knowledge acquired throughout the master course to an academic paper that has a thematic reference to the master program. The thesis can consist of an empirical study or theoretical research. The thesis is an independent piece of work, that, with the guidance of a supervisor, seeks to scientifically analyze and critically discuss a chosen issue, and suggest possible solutions. The chosen topic from the student's area of specialization should demonstrate their acquired competence in the functional area, yet also enrich and round out the student's scientific knowledge. This will optimally prepare the student for the needs of their future career path.

Course Outcomes

On successful completion, students will be able to

- The objective of this module is the completion of a written assignment, in line with scientific methodology, that demonstrates the student's capabilities through independent investigation of a topic pertaining to the master program's area of focus.

Contents

- The master thesis should clearly state the topic and research question, and should, through extensive research, reflect the current state of the field in question. The student should demonstrate their knowledge in the form of an independent and solution oriented paper, using theoretical and/or empirical norms.

Literature

Compulsory Reading

Further Reading

- Bui, Y. N. (2013). How to Write a Master's Thesis (2nd ed.). SAGE Publications, Incorporated.
- Turabian, K. L. (2013). A Manual for Writers of Research Papers, theses, and dissertations (8th ed.). University of Chicago Press.
- Further subject specific literature

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Thesis

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Master Thesis

Student Workload					
Self Study 540 h	**Presence** 0 h	**Tutorial** 0 h	**Self Test** 0 h	**Practical Experience** 0 h	**Hours Total** 540 h

Instructional Methods
☐ Learning Sprints®   ☐ Review Book   ☐ Course Book   ☐ Creative Lab   ☐ Vodcast   ☐ Guideline   ☐ Shortcast   ☐ Live Tutorium/Course Feed   ☐ Audio   ☐ Exam Template

Thesis Defence

Course Code: DLMMTHE02

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		2	See current study and exam regulations (SPO)

Course Description

The thesis defense takes place after the written master thesis has been handed in by the student. The examiners (the supervisor and a second examiner) will invite the student to the defense. During the presentation, the student will demonstrate that he/she personally has independently produced the content and the results of their written thesis. The thesis defense consists of a presentation where the student discusses the most significant research outcomes and the results of their thesis, followed by a question-and-answer session chaired by the examiners.

Course Outcomes

On successful completion, students will be able to

- The main objective of the thesis defense is for the student to prove their competence in research methodology and the specific subject matter. The students should also be able to actively participate in a subject specific discussion at a higher academic level with subject area experts. Additionally, the defense will evaluate the academic presentation skills and overall communication skills of the student.

Contents

- The thesis defense consists of a presentation of the results and applied method of the master thesis, followed by a question-and-answer session chaired by the examiners.

Literature
Compulsory Reading
Further Reading
▪ Subject specific literature chosen by the student

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Thesis Defense

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Presentation: Colloquium

Student Workload					
Self Study 60 h	**Presence** 0 h	**Tutorial** 0 h	**Self Test** 0 h	**Practical Experience** 0 h	**Hours Total** 60 h

Instructional Methods
☐ Learning Sprints® ☐ Review Book   ☐ Course Book ☐ Creative Lab   ☐ Vodcast ☐ Guideline   ☐ Shortcast ☐ Live Tutorium/Course Feed   ☐ Audio   ☐ Exam Template