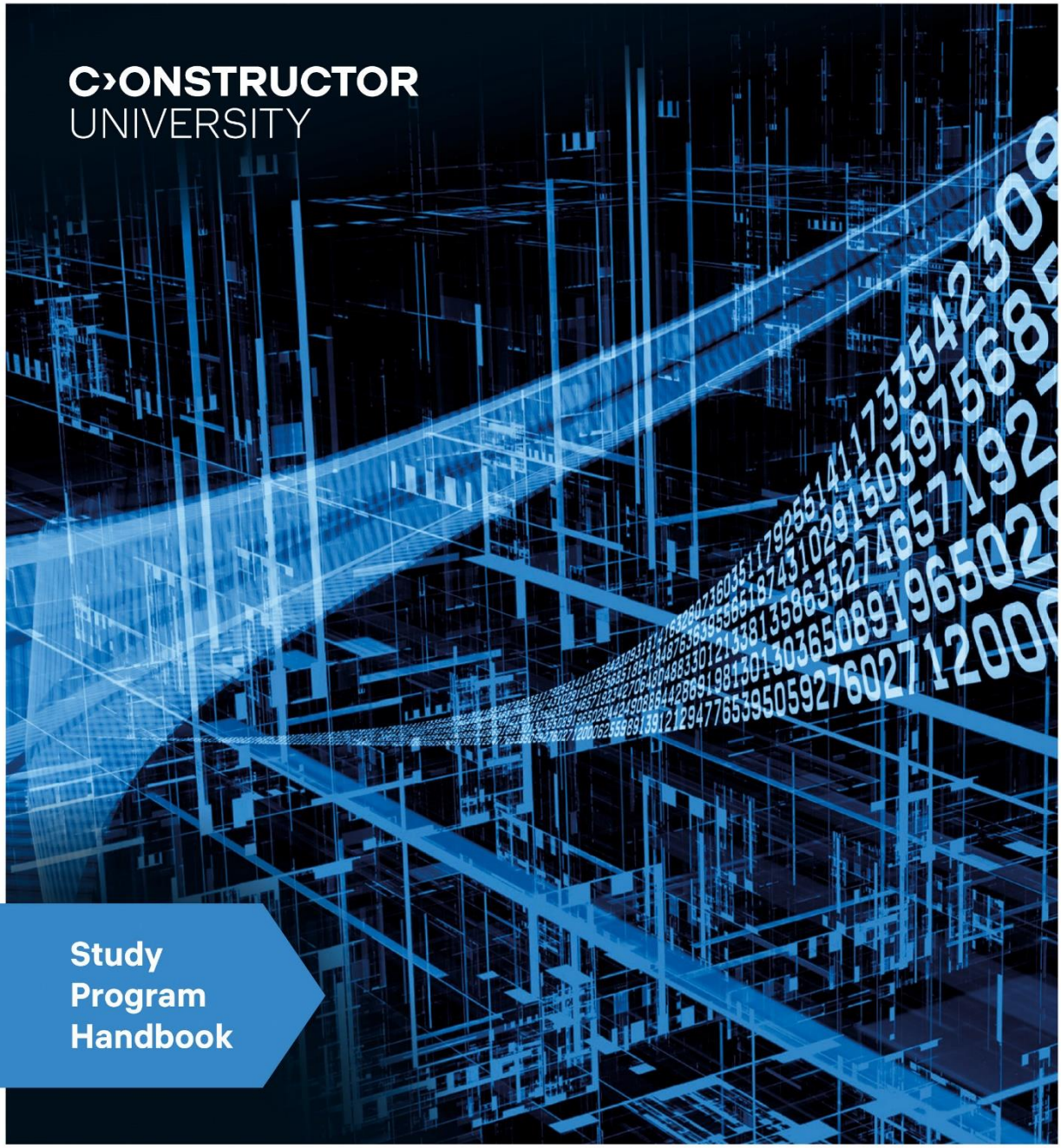

Data Engineering

Master of Science

Subject-specific Examination Regulations for Data Engineering

The subject-specific examination regulations for Data Engineering are defined by this program handbook and are valid only in combination with the General Examination Regulations for Master degree programs ("General Master Policies").

This handbook also contains the program-specific Study and Examination Plan in chapter 2.2

Upon graduation students in this program will receive a Master of Science (MSc) degree with a scope of 120 ECTS credit points (for specifics see chapter 2 of this handbook).

Valid for all students starting their studies in Fall 2025

Study Program Chair: Prof. Dr. Stefan Kettemann

Professor for Complex Systems

skettemann@constructor.university

or visit our program website

https://constructor.university/programs/graduate-education/data-engineering

For more information on Student Services please visit:

https://constructor.university/student-life/student-services

https://constructor.university/programs/graduate-education/data-engineering

Version	Valid as of	Decision	Details
Fall 2025	Sep 01, 2025	Dec 11, 2024.	Restructuring for Reaccreditation, Additional Core Modules. Elective and Method Area Fused into Core Area
Fall 2023 – V1	Sep 01, 2023	Aug 30, 2023	Change of Year 3 Module "Data Visualization and Image Processing" to "Image Processing for Data Engineers"
		Aug 03, 2023	Editorial change of all study schemes
		Aug 28, 2019	Originally approved by the Academic Senate

Contents

1 Program Overview

Today we are ‘‘drowning in data and starving for information”, while acknowledging that ‘‘data is the new gold”. However, deriving value from all the data now available requires a transformation in data analysis, in how we see, maintain, share and understand data. Data Engineering is an emerging profession concerned with the task of acquiring large collections of data and extracting insights from them. It is driving the next generation of technological innovation and scientific discovery, which is expected to be strongly data-driven.

The graduate program in Data Engineering offers a fascinating and profound insight into the methods and technologies of this rapidly growing area. The program combines the big data aspects of “Data Analytics” as well as of “Data Science” with the technological challenges of data acquisition, curation, and management. Thus, the program provides the essentials for paving the way to a successful career: computer skills and mathematical understanding paired with practical experience in selected application fields. Thereby the program aims to educate a new generation of data specialists: Experts for data acquisition, management, analysis and security.

Even though the Data Engineering program is embedded in the School of Computer Science and Engineering, its interdisciplinary nature is taken into account by including courses from the School of Science and the School of Business, Social & Decision Sciences and Advanced Projects in research groups in all schools on campus are an integral part of this study program.

The Data Engineering program attracts students with diverse career goals, backgrounds, and prior work experience. Therefore, the program offers a wide range of elective modules from which the students can choose to specialize further, ranging from modules in Computer Science, Geo-Informatics, Bio-Informatics to Business & Supply Chain Engineering. These elective modules furthermore prepare the students for the Advanced Projects within the Discovery Area and the Master Thesis.

The graduate program in Data Engineering is tailored to a diverse student body (see also Section 1.2) with a wide variety of interests, academic backgrounds, and previous experiences. Small group sizes, a low student-to-teacher ratio, and personalized supervision/advising allow the program to cater a student who has just graduated with a Bachelors’ degree, as well as a person who already has been employed in a data-intensive company and who wants to keep up with current data engineering practices.

1.1 Qualification Aims

1.1.1 Educational Aims

The program aims to provide an in-depth understanding of modern data engineering, and the skills required to apply and implement powerful data engineering and data science methods in a successful and responsible manner. Apart from the necessary programming skills, this comprises:

- methods of data acquisition and data cleaning

- data management methods

- data pipeline and data warehousing methods to efficiently store and process data in large and distributed databases;

- cloud computing methods, usage of cloud infrastructure;

- data mining methods, signal and image processing and machine learning techniques;

- data visualization;

- statistical literacy and competence in sensitivity analysis and robustness;

- legal foundations of Data Engineering;

- scientific qualification;

- competence to take up qualified employment in Data Engineering;

- competence for responsible involvement in society;

- personal growth.

1.1.2 Intended Learning Outcomes

Upon completion of this program, students will be able to

1. Creatively apply and critically assess innovations driven by big data;

2. Design and use databases to efficiently and securely manage and access large amounts of data;

3. Apply statistical concepts and use statistical models in the context of real-life data analytics;

4. Use, adapt and improve visualization techniques to support data-based decision-making;

5. Understand cloud computing concepts, use major cloud platforms and implement cloud solutions;

6. Understand data pipeline concepts, and build and manage data pipelines;

7. Understand the concepts of data warehousing and apply its tools, such as online analytical processing (OLAP), data cubes, data marts and data lakes

8. Design, implement and exploit various representations of data for classification and regression including supervised machine learning methods and core ideas of deep learning;

9. Apply and critically assess data acquisition methods and analytical techniques in real life situations, organizations and industries;

10- Independently investigate complex problems and undertake scientific or applied research into a specialist area utilizing appropriate methods, also taking methods and insights of other disciplines into account;

11. Professionally communicate their conclusions and recommendations, the underlying information and their reasons to both specialists and non-specialists, clearly and unambiguously on the basis of the state of research and application;

12. Assess and communicate social, scientific and ethical insights and consequences of data engineering

13. Engage ethically with the academic, professional and wider communities and actively contribute to a sustainable future;

14. Take responsibility for their own learning, personal development, and role in society, evaluating critical feedback and self-analysis;

15. Take on lead responsibility in a diverse team;

16. Adhere to and defend ethical, scientific and professional standards.

1.2 Target Audience

The Data Engineering graduate program is targeted towards students who have completed their BSc in areas such as computer science, information technology, physics, applied mathematics, statistics, electrical engineering, communications engineering or related disciplines, and who want to deepen their knowledge and proceed to research-oriented work towards a master or ultimately a PhD degree. Typical examples are:

- a student with a bachelor in computer science who wants to acquire skills in data engineering;
- a student with a bachelor in mathematics or physics who wants to capitalize on his/her theoretical knowledge of modeling methods by learning about the hands-on side of data acquisition and analysis, interesting fields for applications, and options for employment;
- a student with a bachelor in geology who wants to become a data engineer and needs to deepen his/her mathematical and statistical skills;
- a student with a bachelor's or master's degree in one of the natural sciences who wishes to boost his/her career in empirical research or industrial research and development, where professional handling of very large-scale data collections has become a prime bottleneck for success;
- a student with an undergraduate degree in the life sciences wishing to expand their skill sets towards data engineering and computational methods in order to apply it to biomedical data.

To facilitate the integration of students with diverse backgrounds, we offer remedial courses in mathematics in the first semester. Placement tests in the orientation week before the first semester starts, help students identify contents they need to refresh or remedy.

1.3 Career Options and Support

The demand for Data Engineers is massive. Typical fields of work encompass the finance sector, the energy industry, the automotive, aviation and health industry as well as retail and telecommunications. Companies and institutions in almost every domain need:

- experts for data acquisition who know how to find, clean and collect the data needed;

- experts for data management who know how to store, enhance, protect and process large amounts of data efficiently;
- experts for data analysis who evaluate and interpret the collected data correctly and can visualize the findings clearly;

Graduates of the program work as data engineers, as data analysts, data managers, data architects, business consultants, software and web developers, or system administrators. An MSc degree in Data Engineering moreover prepares students to move on to a PhD and a career in academia and research institutions.

The employability of MSc Data Engineering graduates is promoted by organizing contacts with industry and research institutes throughout the curriculum. In the first semester, in the Current Topics in Data Engineering seminar, companies and research groups introduce current trends and tools in data engineering and data science and outline current challenges. The students can choose to do advanced projects, in the second and third semesters in research groups on campus or external research institutes, or to do internships in companies. In the second and third semester, participation in public big data challenges is organized as an integral part of the curriculum.

The Career Service Center (CSC) helps students in their career development. It provides students with high-quality training and coaching in CV creation, cover letter formulation, interview preparation, effective presentations, business etiquette, and employer research as well as in many other aspects, thus helping students identify and follow up on rewarding careers after graduating from Constructor University. For further information, please contact the Career Service Center (CSC) (https://constructor.university/student-life/career-services). Furthermore, the Alumni Office helps students establish a long-lasting and worldwide network which provides support when exploring job options in academia, industry, and elsewhere.

1.4 Admission Requirements

The Data Engineering graduate program requires students to have completed their undergraduate program in computer science, physics, applied mathematics, statistics, electrical engineering, communications engineering or related disciplines.

Admission to Constructor University is selective and based on a candidate's university achievements, and self-presentation. Students admitted to Constructor University demonstrate exceptional academic achievements, intellectual creativity, and the desire and motivation to make a difference in the world.

The following documents need to be submitted with the application:

Letter of motivation

Curriculum vitae (CV)

Official or certified copies of university transcripts

Bachelor's degree certificate or equivalent

Language proficiency test results (minimum score of 90 (TOEFL), 6.5 (IELTS) or 110 (Duolingo)).

Copy of Passport

Letter of recommendation (optional).

Formal admission requirements are subject to higher education law and are outlined in the Admission and Enrollment Policy of Constructor University.

For more detailed information about the admission visit:

https://constructor.university/admission-aid/application-information-graduate

2 The Curriculum

2.1 The Curriculum at a Glance

The Data Engineering graduate program is composed of foundational lectures, specialized modules, seminars and applied project work, leading to a master thesis that can be conducted in research groups at Constructor University, at external research institutes or building on an internship a company. The program takes four semesters (two years). The following table shows an overview of the modular structure of the program. The program is sectioned into four areas (Core, Elective, Career and Discovery) and the Master Thesis. All credit points (CP) are ECTS (European Credit Transfer System) credit points. In order to graduate, students need to obtain 120 CP. See Chapter 3 "Modules" of this handbook for the detailed module descriptions or refer to CampusNet.

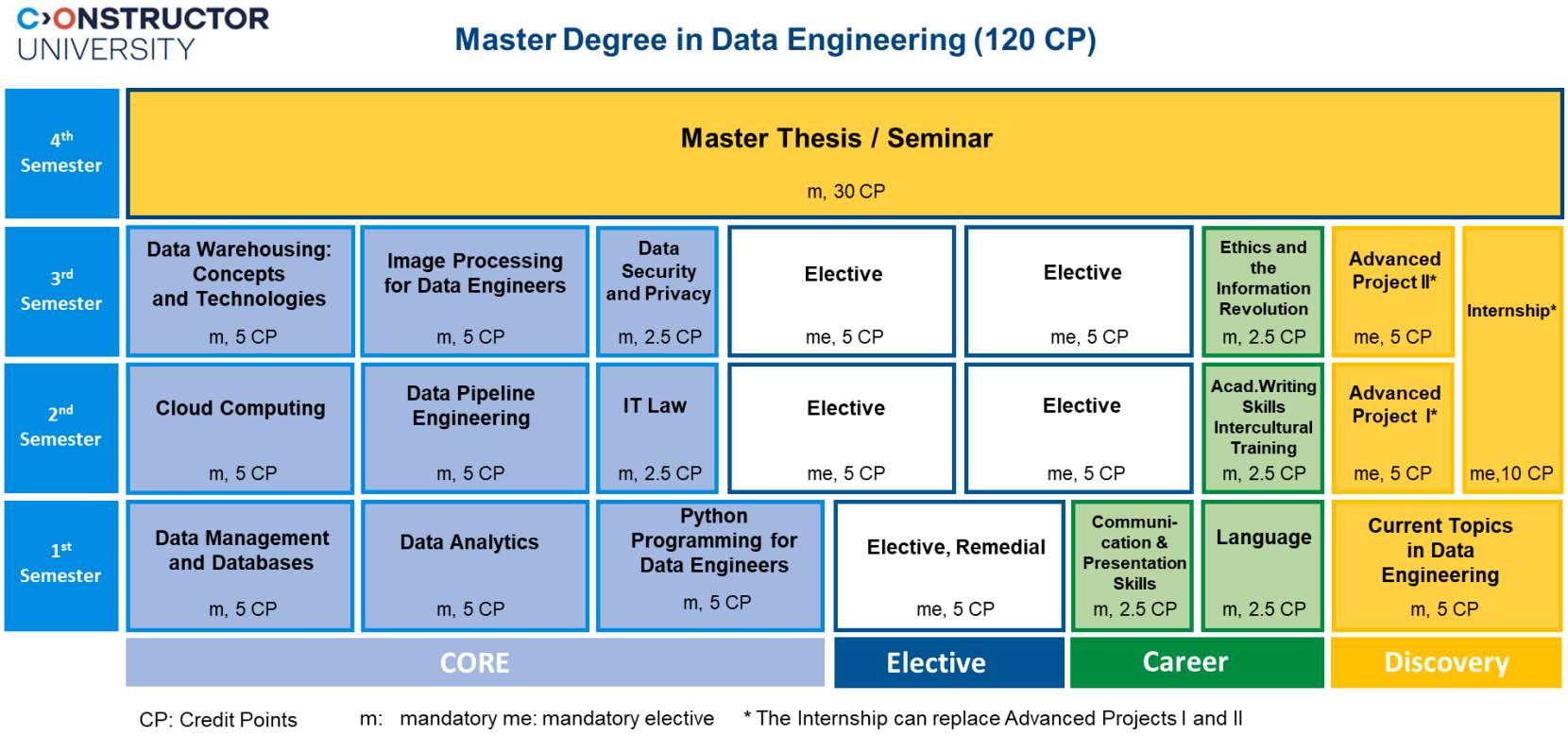

Figure 1: Schematic Study Scheme

2.2 Study and Examination Plan

MSc Degree in Data Engineering Matriculation Fall 2025							
Module Code	**Program-Specific Modules**	**Type**	**Assessment**	**Period[1]**	**Status[2]**	**Semester**	**CP**
Semester 1							**30**
	CORE Area						**15**
MDE-CO-07	**Module: Data Management and Databases**				**m**	**1**	**5**
MDE-CO-07-A	Data Management and Databases	Lecture	Written examination	Examination period			2.5
MDE-CO-07-B	Data Management and Databases- Tutorial	Tutorial	Program Code	During semester			2.5
MDE-CO-02	**Module: Data Analytics**				**m**	**1**	**5**
MDE-CO-02	Data Analytics	Lecture	Project report	During semester			
MDE-CO-08	**Module: Python Programming for Data Engineers**				**m**	**1**	**5**
MDE-CO-08-A	Python Programming for Data Engineers	Lecture	Written examination	Examination period			2.5
MDE-CO-08-B	Python Programming for Data Engineers-Tutorial	Tutorial	Program Code	During semester			2.5
	Elective Area				**me**		**5**
	- students choose one module from those listed below						
	Discovery Area						**5**
MDE-DIS-01	**Module: Current Topics in Data Engineering**				**m**	**1**	
MDE-DIS-01	Current Topics in Data Engineering	Colloquium	Poster Presentation	During semester			
	Career Area						**5**
MDE-CAR-01	**Module: Communication and Presentation Skills for Executives**				**m**	**1**	**2.5**
MDE-CAR-01	Communication and Presentation Skills for Executives	Seminar	Presentation	During semester			
CTLA-	**Module: Language**				**m**	**1**	**2.5**
CTLA-	German	Seminar	Various	Various	m		
Semester 2							**30**
	CORE Area						**12.5**
MDE-CO-09	**Module: Data Pipeline Engineering**				**m**	**2**	**5**
MDE-CO-09-A	Data Pipeline Engineering	Lecture	Written examination	Examination period			2.5
MDE-CO-09-B	Data Pipeline Engineering-Tutorial	Tutorial	Program Code	During semester			2.5
MDE- CO-10	**Module: Cloud Computing**				**m**	**2**	**5**
MDE-CO-10-A	Cloud Computing	Lecture	Written examination	Examination period			2.5
MDE-CO-10-B	Cloud Computing-Tutorial	Tutorial	Program Code	During semester			2.5
MDE-CO-03	**Module: Data Security and Privacy**				**m**	**3**	**2.5**
MDE-CO-03	Data Security and Privacy	Lecture	Written examination	Examination period			
	Elective Area				**me**		**10**
	- Students choose modules from those listed below.						
	Discovery Area						**5**
	- Students choose either Advanced project 1 and 2 or Internship						
MDE-DIS-02	**Module: Advanced Project 1**				**me**	**2**	**5**
MDE-DIS-02	Advanced Project 1	Project work	Project report	During semester			
MDE-INT-01	**Module: Internship DE**				**me**		**10[3]**
MDE-INT-01	Internship DE	Project/ Internship	Project report	During semester		2 and 3	
	Career Area						**2.5**
MDE-CAR-02	**Module: Academic Writing Skills/Intercultural Training**				**m**	**2**	2.5
MDE-CAR-02	Academic Writing Skills/Intercultural Training	Seminar	Term Paper	During semester			

Semester 3								**30**
	CORE Area							**12.5**
MDE-CO-11	**Module: Data Warehousing: Concepts and Technologies**				**m**	**3**		**5**
MDE-CO-11-A	Data Warehousing: Concepts and Technologies	Lecture	Written examination	Examination period				
MDE-CO-05	**Module: Image Processing for Data Engineers**				**m**	**3**		**5**
MDE-CO-05	Image Processing for Data Engineers	Lecture	Written examination	Examination period				
MDSSB-LAW	**Module:IT Law**				**m**	**2**		**2.5**
MDSSB-LAW-01	IT Law	Lecture	Term paper	During semester				
	Elective Area				**me**			**10**
	- Students choose 2 modules from those listed below.							
	Discovery Area							**5**
	- Students choose either Advanced project 1 and 2 or Internship							
MDE-DIS-03	**Module: Acvanced Project 2**				**me**	**3**		**5**
MDE-DIS-03	Advanced Project 2	Project work	Project report	During semester				
	Career Area							**2.5**
MDSSB-EIR-01	**Module: Ethics and the Information Revolution**				**m**	**3**		**2.5**
MDSSB-EIR-01	Ethics and the Information Revolution	Seminar	Term paper	During semester				
Semester 4								**30**
	Master Thesis							**30**
MDE-THE-01	**Module: Master Thesis MSc DE**				**m**	**4**		30
MDE-THE-01	Master Thesis		Thesis	during the semester				
			Oral Examination	during the semester				
Total CP								**120**

[1] Each lecture period lasts 14 semester weeks and is followed by reading and examination days. Written examinations are centrally scheduled during weeks 15 and 16. For all other assessment types, the timeframes indicated

[2] m = mandatory, me = mandatory elective

[3] 10 CP are distributed over two semester, 5CP in 2nd and 5CP in 3rd semester

Elective Area							
Students choose 20 CP of manadatory electives							
MDE-CS-03	**Module: Principles of Statistical Modeling**				**me**	**2**	**5**
MDE-CS-03	Principles of Statistical Modeling	Lecture	Project Report	During semester			
MDE-CS-01	**Module: Network Theory**				**me**	**1 or 3**	**5**
MDE-CS-01	Network Theory	Lecture	Written examination	Examination period			
MDE-CS-04	**Module: Advanced Databases**				**me**	**2**	**5**
MDE-CS-04-A	Advanced Databases	Lecture	Written examination	Examination period			2.5
MDE-CS-04-B	Advanced Databases Lab	Lab	Laboratory Report	During semester			2.5
MDE-CO-01	**Module: Big Data Challenge**				**me**	**1**	**5**
MDE-CO-01	Big Data Challenge	Lecture	Project report	During semester			
MDE-CO-04	**Module: Machine Learning**				**me**	**2**	**5**
MDE-CO-04	Machine Learning	Lecture	Project Report	During semester			
MDE-CO-06	**Module: Data Acquisition Technologies and Sensor Networks**				**me**	**3**	**5**
MDE-CO-06	Data Acquisition Technologies and Sensor Networks	Lecture & Lab	Project report	During semester			
MDE-MET-04	**Module: Modeling and Control of Dynamical Systems**				**me**	**2**	**5**
MDE-MET-04	Modeling and Control of Dynamical Systems	Seminar	Written examination	Examination period			
MDE-GEO-01	**Module: Geoinformatics**				**me**	**1 or 3**	**5**
MDE-GEO-01-A	Geo-Information Systems	Lecture	Term paper	During semester	me		2.5
MDE-GEO-01-B	Introduction to Earth System Data	Lecture			me		2.5
MDE-BIO-01	**Module: Modeling and Analysis of Complex Systems**				**me**	**1 or 3**	**5**
MDE-BIO-01	Modeling and Analysis of Complex Systems	Lecture	Written examination	Examination period			
MDE-BIO-03	**Module: Management and Analysis of Biological and Medical Data**				**me**	**1 or 3**	**5**
MDE-BIO-03	Management and Analysis of Biological and Medical Data	Seminar	Oral examination	Examination period			
MDE-BSC-01	**Module: Data Mining**				**me**	**2**	**5**
MDE-BSC-01	Data Mining	Lecture	Project report	During semester			
MSCM-CO-07	**Module: Data Analytics in Supply Chain Management**				**me**	**3**	**5**
MSCM-CO-07	Data Analytics in Supply Chain Management	Lecture	Project report	During semester			
MDSSB-MET-02	**Module: Text Analysis and Natural Language Processing**				**me**	**2**	**5**
MDSSB-MET-02	Text Analysis and Natural Language Processing	Seminar/Lab	Project report	During semester			
MCSSE-AI-01	**Module: Deep Learning**				**me**	**1 or 3**	**5**
MCSSE-AI-01	Deep Learning	Lecture	Written examination	Examination period			
Total CP							**70**

Remedial Modules							
							10
MDE-MET-01	**Module: Calculus and Linear Algebra for Graduate Students**				**me**	**1**	**5**
MDE-MET-01	Calculus and Linear Algebra for Graduate Students	Lecture	Written examination	Examination period			
MDE-MET-02	**Module: Probabilities for Graduate Students**				**me**	**1**	**5**
MDE-MET-02	Probabilities for Graduate Students	Lecture	Written examination	Examination period			
Total CP							**10**

Figure 2: Study and Examination Plan

2.3 Core Area (45CP)

This area is the centerpiece of the Data Engineering program. The nine mandatory modules in the Core Area cover essential methods of data engineering. They provide the foundations for further, more advanced courses and applied projects by introducing the fundamental concepts, methods and technologies used in data engineering. The modules are intensive courses accompanied by hands-on tutorials and labs.

To pursue a DE master, the following Core modules (40 CP) need to be taken as mandatory modules (m):

- CORE Module: Data Management and Databases (m, 5 CP)
- CORE Module: Data Analytics (m, 5 CP)
- CORE Module: Python Programming for Data Engineering (m, 5 CP)
- CORE Module: Cloud Computing (m, 5 CP)
- CORE Module: Data Pipeline Engineering (m, 5 CP)
- CORE Module: Data Security and Privacy (m, 2.5 CP)
- CORE Module: IT Law (m, 2.5 CP)
- CORE Module: Data Warehousing: Concepts and Technologies (m, 5 CP)
- CORE Module: Image Processing for Data Engineers (m, 5 CP)

2.4 Elective Area (25 CP)

The Data Engineering program attracts students with diverse career goals, backgrounds, and prior work experience. Therefore, modules in this area can be chosen freely by students depending on their prior knowledge and interests. Students can choose to strengthen their knowledge in elective modules in the area of Computer Science, Geo-Informatics, Bio-Informatics, Business & Supply Chain Engineering and Mathematics. These modules can also serve as preparation for the Advanced Projects or the Internship within the Discovery Area and for the Master Thesis.

The following mandatory elective (me) modules can be chosen in the Elective Area:

- Big Data Challenge (me, 5 CP)
- Machine Learning (me, 5 CP)
- Data Acquisition Technologies and Sensor Networks (me, 5 CP)
- Principles of Statistical Modeling (me, 5 CP)
- Advanced Databases (me, 5 CP)
- Network Theory (me, 5 CP)
- Geo Informatics (me, 5 CP)
- Modeling and Analysis of Complex Systems (me, 5 CP)
- Management and Analysis of Biological and Medical Data (me, 5 CP)

- Data Mining (me, 5 CP)
- Data Analytics in Supply Chain Management (me, 5 CP)
- Modeling and Control of Dynamical Systems (me, 5 CP)

In addition to these elective modules, up to one relevant module from other graduate programs and up to one 3rd year modules from the undergraduate curriculum at Constructor University can be taken after consultation with the academic advisor and with the approval of the program coordinator. Please see CampusNet for current offerings.

Particularly relevant elective modules from other graduate programs include

- Text Analysis and Natural Language Processing (DSSB, me 5CP)
- Deep Learning (CSSE, me 5CP)

Constructor University offers special remedial modules, which are recommended to refresh knowledge or to fill knowledge gaps, preparing students to successfully take the Data Engineering Core Area modules. Based on a placement test in the orientation week, the academic advisor will propose which of the modules are useful depending on prior knowledge of the student.

The following remedial modules can be chosen in the Elective area:

- Calculus and Linear Algebra for Graduate Students (me, 5 CP)
- Probabilities for Graduate Students (me, 5 CP)

2.5 Discovery Area (15 CP)

This area features in the first semester a Seminar introducing the students to Current Topics and Challenges in Data Engineering. Lectures are taught by faculty members and invited experts from companies, presenting selected fields of their research activities and interest in data engineering.

This seminar is preparing students for the two advanced projects in Data Engineering in semesters 2 and 3, each of which is worth 5 CP. The projects can be done in the research groups at Constructor University. The advanced projects are supervised by Constructor University faculty in their research groups but can also be done at external research institutes.

A 6-week full-occupation internship (or an equivalent part-time arrangement) with 10CP can replace the two advanced projects of 5CP each. This gives students the opportunity to train, foster, and apply their acquired skills in data engineering in a professional setting. Students engage with the corporate world, learn how to cope and excel in a new environment, and can prepare an application-oriented master thesis, which may facilitate their entry to the job market. The internship content must be relevant to data engineering. Task specifications need to be appropriate for a master's level student. The module coordinator and the Career Service Center will support students in finding suitable positions. The module coordinator also decides on the professional eligibility of the internship. The student needs to submit an internship work program and find a faculty member at Constructor University to be the academic supervisor prior to starting the internship.

The following module is mandatory (m) in the Discovery area:

- Discovery Module: Current Topics in Data Engineering (m, 5 CP)

The following modules are mandatory elective (me) in the Discovery area:

- Discovery Module: Data Engineering Advanced Project I (me, 5 CP)
- Discovery Module: Data Engineering Advanced Project II (me, 5 CP)
- Discovery Module: Data Engineering Advanced Internship (me, 5 CP)

2.6 Career Area (10 CP)

In this area students acquire skills to prepare them for a career as data engineers in industry.

The following modules are mandatory (m) for the career area:

- Career Module: Language (m, 2.5 CP)
- Career Module: Communication & Presentation Skills for Executives (m, 2.5 CP)
- Career Module: Academic Writing Skills / Intercultural Training (m, 2.5 CP)
- Career Module: Ethics and the Information Revolution (m, 2.5 CP)

2.7 Master Thesis (30 CP)

In the fourth semester, students conduct research and write a mandatory master thesis guided and supported by their academic supervisor, worth of 30 credit points.

Thesis Module: Master Thesis (m, 30 CP)

3 Data Engineering Graduate Program Regulations

3.1 Scope of These Regulations

The regulations in this handbook are valid for all students who enter the Data Engineering graduate program at Constructor University in Fall 2025. In case of conflict between the regulations in this handbook and the general Policies for Master Studies, the latter apply (see https://constructor.university/student-life/student-services/university-policies/academic-policies

In exceptional cases, certain necessary deviations from the regulations of this study handbook might occur during the course of study (e.g., change of the semester sequence, assessment type, or the teaching mode of courses).

In general, Constructor University Bremen reserves therefore the right to change or modify the regulations of the program handbook also after its publication at any time and in its sole discretion.

3.2 Degree

Upon successful completion of the program, students are awarded a Master of Science (M.Sc.) degree in Data Engineering.

3.3 Graduation Requirements

In order to graduate, students need to obtain 120 CP and fulfill the requirements outlined in chapter 2 of this handbook.

4 Modules

4.1.1 Data Management and Databases

Module Name	Data Management and Databases
Module Code	2025-MDE-CO-07
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 1 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	

Forms of Learning and Teaching	
Lecture	17.5
Tutorial	17.5
Independent Study	70
Exam Preparation	20
Workload Hours	125 hours

Module Components	Number	Type	CP
Data Management and Databases	MDE-CO-07-A	Lecture	2.5
Data Management and Databases - Tutorial	MDE-CO-07-B	Tutorial	2.5

Module Description

This module provides a comprehensive introduction to data management and database systems, focusing on the design, implementation, and optimization of modern databases. It covers both relational and non-relational databases, emphasizing their roles in handling large-scale and complex data. The aim is to equip students with the skills to address sophisticated data management challenges and to prepare them for the more advanced data engineering modules.

Students will learn the principles of database design, SQL querying, and data management techniques. The module also covers NoSQL databases, providing a comparison with traditional SQL databases.

Content:

- Database design and architecture

- Performance tuning and optimization strategies

- Complex querying techniques and advanced SQL features

- Exploration of NoSQL databases and their applications

- Data storage solutions for big data environments

- Considerations for data security, governance, and compliance

Recommended Knowledge

Read the syllabus

Intended Learning Outcomes

No	Competence	ILO
1	Design	Design and optimize complex database systems tailored to specific requirements.
2	Apply	Apply advanced querying techniques and utilize sophisticated database features.
3	Evaluate	Evaluate and implement various database technologies, including NoSQL solutions.
4	Address	Address challenges related to performance, scalability, and data management.
5	Understand	Understand the importance of data governance, security, and compliance in database systems.

Indicative Literature

- Silberschatz, Korth, and Sudarshan, "Database System Concepts," McGraw-Hill.
- Elmasri and Navathe, "Fundamentals of Database Systems," Pearson
- Kristina Chodorow and Michael Dirolf, "MongoDB: The Definitive Guide," O'Reilly Media.
- Ben Forta, "SQL in 10 Minutes, Sams Teach Yourself," Sams Publishing

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Management and Databases	Written Examination	120 min	50	45%	All
Data Management and Databases - Tutorial	Program Code		50	45%	All

Module Achievements: None

4.1.2 Data Analytics

Module Name	Data Analytics
Module Code	2025-MDE-CO-02
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 1 Mandatory Elective status for: - 2025-AST-MSc 1 - 2025-DSSB-MSc 1 - 2025-CSSE-MSc 1 - 2025-DSSB-MSc 3 - 2025-MDDA-BSc 1 - 2025-MBA-120-MA 1 - 2025-MBA-60-MA 1
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Adalbert F.X. Wilhelm

Forms of Learning and Teaching	
Independent Study	90
Lecture	17.5
Tutorial	17.5
Workload Hours	125 hours

Module Components	Number	Type	CP
Data Analytics	MDE-CO-02	Lecture	5

Module Description

This module introduces concepts and methods of data analytics. The objective of the module is to present methods for gaining insight from data and drawing conclusions for analytical reasoning and decision-making. The module comprises a broad spectrum of methods for modelling and understanding complex datasets. Comprising both descriptive and predictive analytics, the standard portfolio of supervised and unsupervised learning techniques is introduced. Automatic analysis components, such as data transformation, aggregation, classification, clustering, and outlier detection, will be treated as an integral part of the analytics process.

As a central part of this module, students are introduced to the major concepts of statistical learning such as cross-validation, feature selection, and model evaluation. The course takes an applied approach and combines the theoretical foundation of data analytics with a practical exposure to the data analysis process.

Recommended Knowledge

- Read the Syllabus.

- Take the free online course: Introduction to Data Science at https://cognitiveclass.ai/courses/data-science-101/

Usability and Relationship to other Modules

In this module students will learn concepts and various techniques for data analysis. They will be rigorously applied in MDE-CS-03 as well as in the applied projects MDE-DIS-02 and MDE-DIS-03, and typically also in the master thesis.

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain advanced data analytics techniques in theory and application.
2	Apply	Apply data analytics methods to real-life problems using appropriate tools.
3	Evaluate	Evaluate and compare different data analytics algorithms and approaches.
4	Apply	Apply statistical concepts to evaluate data analytics results.

Indicative Literature

- G. James, D.Witten, T. Hastie, Rob Tibshirani: Introduction to Statistical Learning with R by Springer, 2013 (ISLR).
- A. Telea, Data Visualization: Principles and Practice, Wellesley, Mass.: AK Peters, 1st edition, 2008.(DV).
- M. Ward, G. Grinstein, D. Keim, Interactive Data Visualization: Foundations, Techniques, and Applications. AK Peters, 1st edition, 2010. (IDV)

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Analytics	Project Report	20 Pages	100	45%	1-4

Module Achievements: None

4.1.3 Python Programming for Data Engineers

Module Name	Python Programming for Data Engineers
Module Code	2025-MDE-CO-08
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 1 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	

Forms of Learning and Teaching	
Class Attendance	17.5
Tutorial	17.5
Independent Study	70
Exam Preparation	20
Workload Hours	125 hours

Module Components	Number	Type	CP
Python Programming for Data Engineers	MDE-CO-08-A	Lecture	2.5
Python Programming for Data Engineers - Tutorial	MDE-CO-08-B	Tutorial	2.5

Module Description

This module is designed to deepen students' proficiency in Python programming, focusing on concepts and techniques relevant to data engineering. It provides an introduction to core data engineering principles, preparing students for more specialized topics in the field. The course emphasizes practical applications and problem-solving skills, enabling students to develop efficient and scalable solutions to data-related challenges.

Data structures and fundamental algorithms are taught in a hands-on fashion. These will include numerical and data analysis tasks based on NumPy/SciPy. It will include practical applications in data manipulation, analysis, and visualization, with the Python library Pandas. Additionally, key concepts in data engineering, such as data pipelines and data processing, will be introduced to provide context and prepare students for subsequent modules.

Recommended Knowledge

Basic Python programming- refresh your basic Python skills.

Intended Learning Outcomes

No	Competence	ILO
1	Write	Write Python programs using fundamental programming constructs.
2	Utilize	Utilize Python libraries such as Pandas for data manipulation and visualization.
3	Handle	Handle files and data formats (CSV, JSON).

4	Understand	Understand the role and responsibilities of a data engineer.
5	Describe	Describe the components and basic functions of data pipelines.

Indicative Literature

- Mark Lutz, "Learning Python," O'Reilly Media.
- Jake VanderPlas, "Python Data Science Handbook," O'Reilly Media
- Tom White, "Hadoop: The Definitive Guide," O'Reilly Media
- Andreas Müller and Sarah Guido, "Introduction to Machine Learning with Python," O'Reilly Media

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Python Programming for Data Engineers	Written Examination	120 min	50	45%	All
Python Programming for Data Engineers - Tutorial	Program Code		50	45%	All

Module Achievements: None

4.1.4 Cloud Computing

Module Name	Cloud Computing
Module Code	2025-MDE-CO-10
Module ECTS	5
Study Semester	Mandatory status for: Mandatory for DE 2 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	NN

Forms of Learning and Teaching	
Class Attendance	17.5
Tutorial	17.5
Independent Study	70
Exam Preparation	20
Workload Hours	125 hours

Module Components	Number	Type	CP
Cloud Computing	MDE-CO-10-A	Lecture	2.5
Cloud Computing - Tutorial	MDE-CO-10-B	Tutorial	2.5

Module Description

This module introduces students to the foundational concepts and technologies of cloud computing. It covers the basics of cloud platforms, cloud services, and the essential skills needed to set up and manage cloud environments. The aim is to provide students with a strong understanding of cloud computing principles and practical experience with leading cloud platforms such as AWS, Azure, and Google Cloud Platform.

Content:

Introduction to Cloud Computing:

- Definition and characteristics of cloud computing

- Cloud computing service models: IaaS, PaaS, SaaS

- Deployment models: public, private, hybrid, and multi-cloud

- Benefits and challenges of cloud computing

Overview of Major Cloud Platforms:

- Introduction to Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP)

- Key services offered by each platform

Cloud Architecture Fundamentals:

- Understanding cloud infrastructure: compute, storage, and networking

- Virtualization and containerization

- Scalability, elasticity, and high availability

Setting Up Basic Cloud Environments:

- Creating and managing virtual machines (VMs) and instances

- Cloud storage solutions: object storage, block storage, and file storage

- Networking in the cloud: VPCs, subnets, and security groups

Cloud Services and Applications:

- Introduction to cloud databases: RDS, Cosmos DB, Bigtable

- Serverless computing: AWS Lambda, Azure Functions, Google Cloud Functions

- Cloud security basics: IAM, encryption, compliance

Hands-On Labs:

- Setting up a virtual machine on AWS, Azure, and GCP

- Configuring and using cloud storage services

- Deploying a simple web application in the cloud

- Implementing basic security measures

Recommended Knowledge

- Basic knowledge in C/C++

- Mandatory proficiency in Python

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain the fundamental principles and models of cloud computing
2	Describe	Describe the architecture and components of cloud infrastructure
3	Navigate	Navigate and utilize services offered by AWS, Azure, and GCP
4	Set	Set up and manage virtual machines, storage solutions, and networks on these platforms
5	Deploy	Deploy and manage basic cloud-based applications and services
6	Apply	Apply best practices for cloud security and compliance
7	Perform	Perform practical tasks such as setting up VMs, configuring storage, and deploying applications
8	Use	Use cloud platforms' interfaces and tools to manage resources effectively

Indicative Literature

- Thomas Erl, "Cloud Computing: Concepts, Technology & Architecture," Prentice Hall
- Bernard Golden, "Amazon Web Services For Dummies," For Dummies
- Microsoft Azure Documentation: https://docs.microsoft.com/en-us/azure/
- Google Cloud Documentation: https://cloud.google.com/docs/

Entry Requirements

Prerequisites	**Data Management and Databases** **Python Programming for Data Engineers**
Co-requisites	Data Pipeline Engineering
Additional Remarks	

Assessment and Completion

Components	Examination Type	Duration /Length	Weight (%)	Minimum	ILOs
Cloud Computing	Written Examination	120 min	50	45%	All
Cloud Computing - Tutorial	Program Code		50	45%	All

Module Achievements: None

4.1.5 Data Pipeline Engineering

Module Name	Data Pipeline Engineering
Module Code	2025-MDE-CO-09
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 2 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	

Forms of Learning and Teaching	
Class Attendance	17.5
Tutorial	17.5
Independent Study	70
Exam Preparation	20
Workload Hours	125 hours

Module Components	Number	Type	CP
Data Pipeline Engineering	MDE-CO-09-A	Lecture	2.5
Data Pipeline Engineering -Tutorial	MDE-CO-09-B	Tutorial	2.5

Module Description

This module offers an in-depth exploration of data pipeline engineering, focusing on the design, deployment, and management of data pipelines using modern tools and frameworks. Students will learn how to handle large-scale data processing workflows and gain practical experience with open-source technologies such as Apache Airflow, Terraform, and Nomad. The aim is to equip students with the skills and knowledge required to build and manage robust data pipelines, facilitating efficient data flow and processing in cloud environments.

Content:

Course Structure:

1- Introduction to Data Pipelines:

- Definition and importance of data pipelines in data engineering

- Overview of ETL (Extract, Transform, Load) processes

- Components and architecture of data pipelines

2- Tools and Frameworks:

Apache Airflow:

- Introduction to Airflow and its components

- Setting up and configuring Airflow

- Creating and managing DAGs (Directed Acyclic Graphs) for workflow automation

Terraform:

- Basics of Infrastructure as Code (IaC)

- Writing and deploying Terraform scripts

- Automating cloud infrastructure provisioning

Nomad:

- Introduction to Nomad for workload orchestration

- Deploying and managing applications with Nomad

- Integrating Nomad with other tools and services

3- Data Processing Frameworks:

- Overview of batch processing and stream processing

- Introduction to Hadoop and Spark for large-scale data processing

- Hands-on examples and use cases

4- Building and Managing Data Pipelines:

- Designing data pipeline architecture

- Implementing ETL processes using Apache Airflow

- Deploying data pipelines in cloud environments

- Monitoring and troubleshooting data pipelines

5- Advanced Topics:

- Scalability and performance optimization of data pipelines

- Data quality and validation in pipelines

- Security considerations for data pipelines

6- Hands-On Labs:

- Setting up and configuring Apache Airflow

- Writing and deploying Terraform scripts for cloud infrastructure

- Building and deploying a data pipeline using Airflow and Spark

Managing workloads with Nomad

Recommended Knowledge

- Basic knowledge in C/C++

- Mandatory proficiency in Python

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain the importance and components of data pipelines in data engineering.
2	Describe	Describe the ETL processes and their role in data pipelines.
3	Set	Set up and configure Apache Airflow for workflow automation.
4	Write	Write and deploy Terraform scripts for infrastructure provisioning.
5	Use	Use Nomad for workload orchestration and management.
6	Design	Design and implement data pipeline architectures.
7	Deploy	Deploy and manage data pipelines using Airflow, Terraform, and cloud services.
8	Monitor	Monitor and optimize the performance of data pipelines.
9	Perform	Perform practical tasks such as setting up Airflow, writing Terraform scripts and building data pipelines.
10	Apply	Apply best practices for data quality, validation, and security in data pipelines.

Indicative Literature

- Bas P. Harenslak, Julian de Ruiter, "Data Pipelines with Apache Airflow," O'Reilly Media.
- Yevgeniy Brikman, "Terraform: Up & Running," O'Reilly Media.
- HashiCorp Documentation for Nomad: https://www.nomadproject.io/docs/

Entry Requirements

Prerequisites	Data Management and Databases Python Programming for Data Engineers
Co-requisites	Cloud Computing
Additional Remarks	

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Pipeline Engineering	Written Examination	120 min	50	45%	All
Data Pipeline Engineering	Program Code		50	45%	All

Module Achievements: None

4.1.6 IT Law

Module Name	IT Law
Module Code	2025-MDSSB-LAW
Module ECTS	2.5
Study Semester	Mandatory status for: - 2025-DE-MSc 2 Mandatory Elective status for: - 2025-DSSB-MSc 2
Duration	1 Semester
Program Affiliation	2025-DSSB-MSc (Data Science for Society and Business)
Module Coordinator(s)	Prof. Dr. Hilke Brockmann Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Lecture	17.5
Independent Study	45
Workload Hours	62.5 hours

Module Components	Number	Type	CP
IT Law	MDSSB-LAW-01	Lecture	2.5

Module Description

Digital information, the Internet, and applications like YouTube or social networking tools like Instagram, Facebook, or Twitter have disrupted legal systems (Murray 2016). IT law is not limited to one legal area but encompasses civil, public, and criminal laws. It spans from human rights law to intellectual property law, contract and consumer protection law, privacy law, data protection law, and other legal domains. Moreover, the global exchange of data is in conflict with the territorial principle of jurisdiction. In addition, IT regulations are in a constant flux to keep up with the accelerated pace of technological progress. This module looks into the most important areas of IT law. It provides the participants with a sound understanding of legal principles and regulations, and sheds light on international as well as European ICT policies and governance. A special focus will be given to the European General Data Protection Regulation (GDPR).

Usability and Relationship to other Modules

For DSSB students: It is one of the three Career modules (IT Law, Language III, and Ethics and the Information Revolution) that can be chosen for replacement by the internship. Students need to replace 10 CP for the internship.

Recommended Knowledge

Read the Syllabus

Intended Learning Outcomes

No	Competence	ILO

1	Identify	Identify legal questions and implications in relation to digital transformation technologies/IT law/ AI and algorithms.
2	Understand	Understand fundamental national and international legal frameworks related to the use of data.
3	Know	Know the relevant IP rights regarding data and algorithms.
4	Understand	Understand and critically assess legal regulations about data privacy and data protection.
5	Recognize	Recognize and explain the types of bias inherent in data processing.
6	Explain	Explain the legal concerns related to data-based automatic decision making.
7	Understand	Understand how to comply to the GDPR and assess its impact on individuals, firms, and organizations.
8	Understand	Understand and critically evaluate the liabilities and available remedies with regard to data.
9	Explain	Explain and develop potential future IT regulation mechanisms.

Indicative Literature

- Lloyd (2020). Information Technology Law. Oxford: Oxford University Press (9th ed).

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
IT Law	Term Paper	3,500 words	100	45%	1-9

Module Achievements: None

4.1.7 Data Security and Privacy

Module Name	Data Security and Privacy
Module Code	2025-MDE-CO-03
Module ECTS	2.5
Study Semester	Mandatory status for: - 2025-DE-MSc 1 - 2025-DE-MSc 3 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Seminar	17.5
Independent Study	45
Workload Hours	62.5 hours

Module Components	Number	Type	CP
Data Security and Privacy	MDE-CO-03	Lecture	2.5

Module Description

Data Security and Privacy introduces concepts of data security. Basic cryptographic mechanisms are introduced, and it will be explained how these mechanisms can be used to protect data during transmission over the Internet or while data is stored on computing systems. The module component will also introduce the technical aspects of data privacy and concepts such as anonymity, linkability, observability and pseudonymity.

Recommended Knowledge

Read the syllabus

Intended Learning Outcomes

No	Competence	ILO
1	Analyze	Analyze and develop principles for public key encryption.
2	Assess	Assess and choose appropriate techniques for authentication.
3	Understand	Understand the design of internet standards.
4	Summarize	Summarize and communicate the principles behind encryption using shared keys.
5	Critically	Critically assess and identify how security issues are solved and how this will impact the security of applications.

Indicative Literature

- D. R. Stinson, Cryptography: Theory and Practice, ISBN, 1-58488-206-9, Chapman & Hall. 4th edition, 2018. https://ebookcentral.proquest.com/lib/jacob/detail.action?docID=5493336.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Security and Privacy	Written Examination	90 minutes	100	45%	1-5

Module Achievements: None

4.1.8 Data Warehousing: Concepts and Technologies

Module Name	Data Warehousing: Concepts and Technologies
Module Code	2025-MDE-CO-11
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 3 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Data Warehousing: Concepts and Technologies	MDE-CO-11	Lecture	5

Module Description

Enterprises at any time need to know where their business stands in order to make the right decisions. Obviously, manifold internal and external factors have an impact and hence have to be gathered and combined to achieve the best possible decision support for the managers. The software technology aiming at this goal, summarized as Business Intelligence (BI), performs various tasks such as information collection and homogenization, analytics and data mining, and visualization through dashboards etc.

From an information management perspective, the central BI component is the Data Warehouse (DW), a subject-oriented, integrated, time-variant, non-volatile pool of data supporting management decision processes. The analytics carried out is subsumed as Online Analytical Processing (OLAP), the central structure is that of a multi-dimensional OLAP datacube.

In this course, an introduction to Data Warehousing is given. First an introduction to the world of warehousing is presented, followed by a software architecture perspective. A deep dive into the information management aspect inspects OLAP databases and datacubes (with all implications such as query workloads, normal forms, query optimization, etc.), the challenges to extract, transform, and load (ETL) to continuously feed the warehouse, and tools for getting insight from datacubes, ranging from simple spreadsheets to complex data mining. The plot finalizes with a glance at current research issues.

Structure

- Motivation: Why Data Warehouses?

- Warehouse Architectures for Merging Information Resources

- Data Warehouse Architecture

- OLAP Databases: ROLAP, MOLAP, and More

- Variations: Data Marts, Data Lakes, Data Ecosystems

- Collecting Data: ETL

- Analyzing Data: from Spreadsheets to Data Mining

- Wrap-Up & Research Issues

Intended Learning Outcomes

No	Competence	ILO
1	Understand	Understand the data management and analytics requirements of Business Intelligence
2	Explain	Explain the core concepts of Data Warehousing towards management decision support
3	Explain	Explain the need for data cleansing when harvesting from heterogeneous sources, give examples for problems that may arise, and explain benefits and limits of ETL tool
4	Understand	Understand the concepts of OLAP and OLAP datacubes
5	Design	Design an OLAP datacube schema for some given Warehouse description, using a relational database (ROLAP)
6	Formulate	Formulate typical ROLAP analytics queries on a given ROLAP schema
7	Explain	Explain the different OLAP approaches of ROLAP, MOLAP, HOLAP, and DOLAP
8	Correlate	Correlate and differentiate Warehousing and related terminology such as datacubes vs. data marts vs. data lakes

Indicative Literature

- R. Kimball, M. Ross: The Data Warehouse Toolkit. 3rd Edition, Wiley, 2013, ISBN-10: 1118530802
- Barry Devlin: Cloud Data Warehousing Volume I: Architecting Data Warehouse, Lakehouse, Mesh, and Fabric. Technics Publications, 2023, ISBN-10: 1634623363

Entry Requirements

Prerequisites	Data Analytics Data Management and Databases
Co-requisites	None
Additional Remarks	

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Warehousing: Concepts and Technologies	Written Examination	120 min	100	45%	All

Module Achievements: None

4.1.9 Image Processing for Data Engineers

Module Name	Image Processing for Data Engineers
Module Code	2025- MDE-CO-05
Module ECTS	5
Study Semester	Mandatory status for: 2025-DE-MSc-3 Mandatory Elective status for: 2025-PHDS-MSc-3
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Markus Wenzel

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Image Processing for Data Engineers	MDE-CO-05	Lecture	5

Module Description

Images are ubiquitous in society and science. All kinds of sensors turn physical phenomena into visual representations that we interpret to learn, take decisions, or just enjoy. In parallel, digital imaging sensors have become a commodity, resulting in massive amounts of images stored on the internet. They contain implicit knowledge about our world, and it is a data engineers' task to be able to extract their information and generate knowledge from it.

Appreciating this central role of image in data science and data engineering, this module introduces the basic concepts and applications of image processing for data engineers. This module's aim is to enable students:

- To understand the relation of physical phenomena and their image representation, including sensors that don't necessarily yield human-interpretable images,
- To acquire, store, retrieve, and work with image data in an efficient way,
- To transform images using different methods from hand-crafted algorithms to machine learning and deep learning pipelines,
- And to perform operations on them to extract useful information and knowledge.

This course introduces sampling and quantization strategies, elementary image transformations, and higher-level information extraction techniques like noise reduction, image segmentation, and feature extraction leading up to image analysis automation.

The module will be taught along real-world applications relevant for data engineers, such as in biomedical imaging, pattern recognition and classification. It will provide an overview of the broader

field of image processing. Homework assignments will cover Python implementations of basic and combined image processing algorithms.

Recommended Knowledge

- Basic linear algebra, calculus and programming skills

- Reading the syllabus is recommended

Intended Learning Outcomes

No	Competence	ILO
	Understand	Understand and describe types of imaging physics, implemented in common sensor technologies used to acquire images (e.g. radiation, emission, and transmission imaging, and examples of each)
	Explain	Explain basic concepts of image processing like pixel-wise transforms, neighborhood transforms, and how elementary transforms can be composed into image analysis, on the example of morphological image processing
	Apply	Apply sampling and quantization strategies
	Understand	Understand and compare common methods for image segmentation, like region growing, connected components, or the watershed transform,
	Know	Know algorithms for edge, corner, and interest point detection like Canny edges, Harris corners, others
	Compare	Compare noise reduction methods by their principles, and select appropriate methods based on a given use case, like Gaussian blurring, bilateral filters, anisotropic diffusion filters
	Perform	Perform feature extraction from images using methods from categories like shape features, intensity features, texture features, interest point descriptors
	Apply	Apply machine learning to features derived from images
	Know	Know common techniques for deep-learning-based image processing, like CNNs for classification and segmentation, GANs for image generation, and Transformers for multi-purpose image processing
	Design	Design and implement their own image processing algorithms in Python and apply these to real world examples

Entry Requirements

Prerequisites	**None**
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs

Image Processing for Data Engineers	Written Examination	120 minutes	100	45%	1-3

Module Achievements: None

4.1.10 Big Data Challenge

Module Name	Big Data Challenge
Module Code	2025-MDE-CO-01
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 1 - 2025-SCM-MSc 1 Mandatory Elective status for: - 2025-MBA-120-MA 1 - 2025-MBA-60-MA 1
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Adalbert F.X. Wilhelm

Forms of Learning and Teaching	
Lecture	17.5
Project Work	90
Independent Study	17.5
Workload Hours	125 hours

Module Components	Number	Type	CP
Big Data Challenge	MDE-CO-01	Lecture	5

Module Description

Big data is one of the buzz words of the current decade and refers to the collection and exploration of complex data sets. This complexity of big data is typically described by the four V's: Volume, Velocity, Variety, and Veracity. From a business perspective, big data is often portrayed as a sea of big opportunities. The public debate is torn between the two poles portrayed by the writers George Orwell and Aldous Huxley: complete surveillance resulting in oppression on the one end, and irrelevance and narcissism on the other. Technological research quite naturally is mostly concerned with the technical feasibility of different approaches, the continuously increasing challenges with respect to the four V's, and the creative solutions needed to tackle them.

In this module students receive an overview of big data by looking at it from various perspectives, primarily the business and societal points of view. The focus is not on the technical methods and skills, but on case studies that show big data and data engineering in a cross-section.

Recommended Knowledge

- Researching information, assessing sources and report writing

- Read the Syllabus

- Read Susan Ettlinger (2015). What Do we do with all this Big Data? Altimeter. https://www.prophet.com/2015/01/new-research-what-do-we-do-with-all-this-big-data/

- Watch corresponding TEDTalk

Usability and Relationship to other Modules

- For DE: This module provides an overview on practical big data applications. The computational details will then be studied in MDE-CS-04.

- For SCM: Concepts are applied in MSCM-CO-03 Trends & Challenges in Supply Chain Management. Project management concepts taught in MSCM-CO-01 will be applied. Academic writing skills taught in MSCM-CAR-01 facilitate the completion of the tasks in this module.

Intended Learning Outcomes

No	Competence	ILO
1	Contribute	Contribute knowledgeably to the current debate about big data, digitalization and industry 4.0.
2	Explain	Explain and discuss pros and cons of digitalization from a business perspective as well as a societal perspective.
3	Perform	Perform a SWOT analysis on current big data initiatives.
4	Evaluate	Evaluate technological possibilities and innovations driven by big data.
5	Assess	Assess the business opportunities of current big data developments.

Indicative Literature

- McLellan (2013): Big Data: An Overview https://www.zdnet.com/article/big-data-an-overview/
- S. Akter & S. Fosso Wamba, Big data analytics in e-commerce: A systematic review and agenda for future research, 2016. Electronic Markets, 26 173-194.
- Z. Lv, H. Song, P. Basanta-Val, A. Steed and M. Jo. "Next-Generation Big Data Analytics: State of the Art, Challenges, and Future Research Topics," in IEEE Transactions on Industrial Informatics, vol. 13, no. 4, pp. 1891-1899, Aug. 2017.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Big Data Challenge	Project Report	2500 words	100	45%	1-5

Module Achievements: None

4.1.11 Machine Learning

Module Name	Machine Learning
Module Code	2025-MDE-CO-04
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 2 Mandatory Elective status for: - 2025-DSSB-MSc 2 - 2025-CSSE-MSc 2 - 2025-MBA-120-MA 2
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Machine Learning	MDE-CO-04	Lecture	5

Module Description

Machine learning (ML) is a module that concerns algorithms that are fed with (large quantities of) real-world data, and which return a compressed "model" of the data. An example is the "world model" of a robot: the input data are sensor data streams, from which the robot learns a model of its environment. Another example is a spoken language model: the input data are speech recordings, from which ML methods build a model of spoken English -- useful, for instance, in automated speech recognition systems. There are many formalisms in which such models can be cast, and an equally large diversity of learning algorithms. At the same time, there is a relatively small number of fundamental challenges that are common to all of these formalisms and algorithms.

The module introduces such fundamental concepts and illustrates them with a choice of elementary model formalisms (linear classifiers and regressors, radial basis function networks, clustering, neural networks). Furthermore, the module also (re)introduces required mathematical material from probability theory and linear algebra. The main educational aims are twofold: to make students fully aware of the two main hurdles for obtaining good models from data: (i) the "curse of dimensionality" and (ii) the bias-variance dilemma and to provide standard tools to cope with these difficulties, namely (i) dimension reduction by feature extraction, for example via PCA or clustering, and (ii) cross-validation and regularization.

Usability and Relationship to other Modules

This module is a natural companion to the "Principles of Statistical Modeling" (PSM) module MDE-CS-03.

The ML module focuses on practical ML skills, whereas PSM module on rigorous mathematical formalism and analysis.

For students not familiar with graph theory, it is recommended to take the first semester course MDE-CS-01 Network

Theory, which introduces concepts used in this Machine Learning module.

Recommended Knowledge

- Basic linear algebra, calculus and probability theory, as typically acquired in entry modules in BSc studies.

- Read the syllabus.

- Highly recommended: Mitchell, Tom M.: Machine Learning (McGraw-Hill, 1997) IRC: Q325.5.M58 1997. This standard, classical textbook gives a very accessible overview of ML.

Intended Learning Outcomes

No	Competence	ILO
1	Design	Design, implement and exploit elementary supervised ML methods for classification and regression with expert care given to dimension reduction preprocessing and regularization
2	Understand	Understand and practically use PCA and linear regression
3	Understand	Understand the core ideas behind feedforward neural networks and the backpropagation algorithm, as the basis for accessing "deep learning" methods

Indicative Literature

- T. M. Mitchel, Machine Learning, McGraw-Hill, 1997, IRC: Q325.5.M58.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Machine Learning	Written Examination	120 minutes	100	45%	1-3

Module Achievements: None

4.1.12 Data Acquisition Technologies and Sensor Networks

Module Name	**Data Acquisition Technologies and Sensor Networks**
Module Code	2025-MDE-CO-06
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 3 - 2025-DE-MSc 4 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Dr. Fangning Hu

Forms of Learning and Teaching	
Lecture/Laboratory	35
Independent Study	90
Workload Hours	125 hours

Module Components	**Number**	**Type**	**CP**
Data Acquisition Technologies and Sensor Networks	MDE-CO-06	Lecture and Laboratory	5

Module Description

Medical monitoring, smart cars, smart grids, smart homes, and ubiquitous connections to the internet everywhere: There will be an ocean of data not only entered by humans but also automatically pouring in from billions of sensors deployed in a plethora of devices. How are such data collected, and how can they be made available to you, to your doctor, or to other users? These are only some of the questions to be addressed. This module offers a hands-on introduction to the technology behind the scenes. Topics include microcontrollers; how to program them; the way they interact with sensors and actuators; and the wireless techniques they use to communicate with each other, with other computers, and with the internet.

As the module covers a wide range of platforms, it also utilizes aspects from a variety of different languages and devices. To be successful, it helps to be familiar with basic electrical circuits, microcontrollers, HTML, PHP, SQL, C, and Python. Although there will be a lot of support, it is recommended to be familiar with at least a few of these aspects.

Recommended Knowledge

- The students should be familiar with at least some of the following topics: basic electrical circuits, microcontrollers, HTML, PHP, SQL, C, and Python.

- Read the syllabus.

- A lab manual will be provided, reading the lab manual before each lab session is recommended.

Usability and Relationship to other Modules

This module offers the techniques of wireless acquisition of the data that will later be processed and analyzed by techniques studied in the Data Analytics module MDE-CO-02, the Machine Learning module MDE-CO-04, and the Data Analytics in Supply Chain Management module MSCM-CO-07.

Intended Learning Outcomes

No	Competence	ILO
1	Acquire	Acquire data from different sensors and use a microcontroller to process them.
2	Transmit	Transmit data from the microcontroller to a database on a server.
3	Collect	Collect data from web browsers and transmit them to a database on a server.
4	Visualize	Visualize the data on computers or smart devices.
5	Set	Set up a wireless sensor network and communicate data among different components.

Indicative Literature

- M. Kooijman, Building wireless sensor networks using Arduino: leverage the powerful Arduino and XBee platforms to monitor and control your surroundings, Packt Publishing, 2015 ISBN:9781784397159 1784397156.
- H. E Williams, D. Lane, Web database applications with PHP and MySQL, O'Reilly Media, 2004, ISBN: 0596005431 9780596005436.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Acquisition Technologies and Sensor Networks	Project Report	20 pages	100	45%	1-5

Module Achievements: None

4.1.13 Principles of Statistical Modeling

Module Name	Principles of Statistical Modeling
Module Code	2025-MDE-CS-03
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 2
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Principles of Statistical Modeling	MDE-CS-03	Lecture	5

Module Description

This module introduces the basic concepts of statistical modeling. The focus is on a thorough understanding of fundamental concepts: the nature of probability spaces and random variables; distributions and their representations; design and critical assessment of real-life samples; statistical hypothesis testing; statistical decision-making; strategies for estimator design. This module is distinguished from standard probability courses for non-mathematical audiences in that the mathematical model of „probability" is rigorously introduced, including sigma-fields.

The primary educational aim is to lift students to a level of mastery and understanding of the intricate formalism of probability and statistics that enables them to read the respective scientific literature and to adapt existing algorithms or even develop new algorithms. This module is thus targeted at students who want to go beyond a mere mechanical use of existing statistical toolboxes, and develop innovative data analysis techniques of their own design.

The secondary educational aims are to enable students to (i) understand the substantial differences between methodological approaches and fundamental mindsets in statistics vs. machine learning and (ii) understand the differences between and respective advantages and disadvantages of classical frequentist vs. Bayesian modeling methods.

Recommended Knowledge

- Basic linear algebra, calculus and probability theory, as typically acquired in entry modules in BSc studies.

- Read the syllabus

Usability and Relationship to other Modules

The Machine Learning module MDE-CO-04 and the Data Analytics module MDE-CO-02 are complementary in that they introduce and focus on practical tools and techniques, whose theoretical foundations only can become fully clear in this module.

Intended Learning Outcomes

No	Competence	ILO
1	Correctly	Correctly and insightfully use the core formalism of probability theory.
2	Understand	Understand the (basic) formalism used in the scientific literature of machine learning and statistics.
3	Decide	Decide which type of approach is indicated to address a given modeling task (frequentist vs. Bayesian; black-box-modeling in machine learning spirit vs. statistical decision procedures; maximum-likelihood vs. Bayesian vs. unbiasedness criteria for procedure selection).
4	Appreciate	Appreciate the importance of being exact and circumspective in setting up statistical modeling procedures.

Indicative Literature

- H. Jäger, Principles of Statistical Modeling, online tutorial http://minds.jacobs-university.de/teaching/courses/t2019psm/.
- V. Vapnik, The Nature of Statistical Learning Theory, Springer-Verlag, 1995.
- R. J. Hyndman, G. Athanasopoulos Forecasting, Principles and Practice, , online script, https://otexts.com/fpp2/.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Principles of Statistical Modeling	Project Report	10 pages	100	45%	1-4

Module Achievements: None

4.1.14 Network Theory

Module Name	Network Theory
Module Code	2025-MDE-CS-01
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 1 - 2025-DE-MSc 3
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Network Theory	MDE-CS-01	Lecture	5

Module Description

The theory of networks - as diverse as power grids, computer networks, social networks, and biological networks - has emerged in recent years as a highly dynamic and rapidly developing discipline. The study of networks is broadly interdisciplinary and important developments have occurred in many fields, including mathematics, physics, computer and information sciences, biology, and the social sciences. This module introduces this field, starting with a review of the diverse realizations of networks. We then teach how to measure the structure of networks and introduce methods for analyzing network data.

We introduce graph theory, which forms the basis of network theory. Then, we review computer algorithms and spectral methods to analyze networks. We introduce various mathematical models of networks, including random graph models and generative models, and conclude with more recent theories that model the dynamical processes taking place on networks.

Recommended Knowledge

- Basic linear algebra, calculus and probability theory, as typically acquired in entry modules in BSc studies.

- Read the syllabus. Refresh your Linear Algebra. Read the first two chapters of the primary book Networks: An Introduction by M.E.J Newman, ISBN 9780199206650 (2010)

Usability and Relationship to other Modules

This course prepares for the courses MDE-CO-04 Machine Learning and MDE-CS-03 Principles of Statistical Modeling.

Intended Learning Outcomes

No	Competence	ILO
1	Measure	Measure structure of networks.
2	Analyze	Analyze network data.
3	Perform	Perform the modeling of dynamic processes on networks.
4	Communicate	Communicate in scientific language using advanced field-specific technical terms.

Indicative Literature

- M. Newman, Networks an Introduction, Oxford Univ. Press, 2010, ISBN: 9780199206650.
- A.-L. Barabasi, Network Science, Cambridge University Press, Cambridge, 2016, ISBN-10: 1107076269.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Network Theory	Written Examination	120 minutes	100	45%	1-4

Module Achievements: None

4.1.15 Advanced Databases

Module Name	Advanced Databases
Module Code	2025-MDE-CS-04
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 2 - 2025-CSSE-MSc 2
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Peter Baumann

Forms of Learning and Teaching	
Lecture	40
Laboratory	40
Independent Study	45
Workload Hours	125 hours

Module Components	Number	Type	CP
Advanced Databases	MDE-CS-04-A	Lecture	2.5
Advanced Databases Lab	MDE-CS-04-B	Laboratory	2.5

Module Description

This course deepens knowledge and skills in managing and serving Big Data with emphasis on flexibility and scalability. As a result of this course, students will know the state of the art in data management for particularly large and complex data, including in cloud-based data setups. Based on the Data Engineering Core lecture Data Management the course starts with a reinspection of classical SQL, preparing an overview of SQL query processing.

Based on this understanding opportunities of optimization and parallelization are discussed. Subsequently, novel developments in Big Data services are discussed. NoSQL approaches with their new data models are inspected, such as documents, graphs and arrays. This is contrasted with NewSQL and their novel techniques for competitive performance. Dedicated architectures are discussed, such as MapReduce.

This leads to general scalability considerations, with an emphasis on large-scale parallel and distributed processing. Throughout the course practical considerations play an important role, including practitioner hints on database modeling, tuning, and security. Practical guided hands-on exercises complement this.

Usability and Relationship to other Modules

For DE: pre-requisite Introduction to Data Management with Python.

Recommended Knowledge

- Mandatory knowledge of SQL

- Working knowledge of fundamental data structures, such as trees

- Working knowledge of computer architectures

- Good command of at least one programming language, as several languages will be used in the lab

Intended Learning Outcomes

No	Competence	ILO
1	Summarize	Summarize the state of the art in data management for particularly large and complex data.
2	Establish	Establish criteria for selecting adequate scalable data management technology based on various criteria.
3	Establish	Establish a state-of-the-art database schema for a given application scenario.
4	Tune	Tune a relational database for best performance on some given query workload.
5	Adequately	Adequately consider security aspects in databases.
6	Develop	Develop applications using Web and database technology.

Indicative Literature

- McLellan (2013): Big Data: An Overview https://www.zdnet.com/article/big-data-an-overview/.
- S. Akter & S. Fosso Wamba, Big data analytics in e-commerce: A systematic review and agenda for future research, 2016. Electronic Markets, 26 173-194.
- Z. Lv, H. Song, P. Basanta-Val, A. Steed and M. Jo. "Next-Generation Big Data Analytics: State of the Art, Challenges, and Future Research Topics," in IEEE Transactions on Industrial Informatics, vol. 13, no. 4, pp. 1891-1899, Aug. 2017.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Advanced Databases	Written Examination	120 minutes	67	45%	1,2,3,4,5
Advanced Databases Lab	Laboratory Report		33	45%	3,4,5,6

Module Achievements: None

4.1.16 Geoinformatics

Module Name	Geoinformatics
Module Code	2025-MDE-GEO-01

Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DSSB-MSc 1 - 2025-DE-MSc 1 - 2025-DSSB-MSc 3 - 2025-DE-MSc 3
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Vikram Unnithan

Forms of Learning and Teaching	
Lecture	40
Practical Assignments	40
Independent Study	45
Workload Hours	125 hours

Module Components	**Number**	**Type**	**CP**
Geo-Information Systems	MDE-GEO-01-A	Lecture	2.5
Introduction to Earth System Data	MDE-GEO-01-B	Lecture	2.5

Module Description

Machine learning (ML) is a module that concerns algorithms that are fed with (large quantities of) real-world data, and which return a compressed "model" of the data. An example is the "world model" of a robot: the input data are sensor data streams, from which the robot learns a model of its environment. Another example is a spoken language model: the input data are speech recordings, from which ML methods build a model of spoken English -- useful, for instance, in automated speech recognition systems. There are many formalisms in which such models can be cast, and an equally large diversity of learning algorithms. At the same time, there is a relatively small number of fundamental challenges that are common to all of these formalisms and algorithms.

The module introduces such fundamental concepts and illustrates them with a choice of elementary model formalisms (linear classifiers and regressors, radial basis function networks, clustering, neural networks). Furthermore, the module also (re) introduces required mathematical material from probability theory and linear algebra. The main educational aims are twofold: to make students fully aware of the two main hurdles for obtaining good models from data: (i) the "curse of dimensionality" and (ii) the bias-variance dilemma and to provide standard tools to cope with these difficulties, namely (i') dimension reduction by feature extraction, for example via PCA or clustering, and (ii') cross-validation and regularization.

Recommended Knowledge

- Basic computer skills, basic working knowledge of Linux OS and Python

- Read the Syllabus

- Geographic Information Systems and Science, 2nd Edition (2005) Paul A. Longley, Michael F. Goodchild, David J. Maguire, David W. Rhind. Wiley, 560 p. ISBN 0470721448.

- Python Data Science Handbook, Jake VanderPlas, 2016 - https://jakevdp.github.io/PythonDataScienceHandbook/

Usability and Relationship to other Modules

- This module is a natural companion to the "Principles of Statistical Modeling" (PSM) module MDE-CS-03.

- The ML module focuses on practical ML skills, whereas PSM module on rigorous mathematical formalism and analysis.

- For students not familiar with graph theory, it is recommended to take the first semester course MDE-CS-01 Network Theory, which introduces concepts used in this Machine Learning module.

Intended Learning Outcomes

No	Competence	ILO
1	Design	Design, implement and exploit elementary supervised ML methods for classification and regression with expert care given to dimension reduction preprocessing and regularization.
2	Understand	Understand and practically use PCA and linear regression.
3	Understand	Understand the core ideas behind feedforward neural networks and the backpropagation algorithm, as the basis for accessing "deep learning" methods.

Indicative Literature

- P. A. Longley, M. F. Goodchild, D. J. Maguire, D. W. Rhind, Geographic Information Systems and Science, 2nd Edition, Wiley, 2005, 560 p. ISBN 0470721448.
- Jake VanderPlas, Python Data Science Handbook, 2016, https://jakevdp.github.io/PythonDataScienceHandbook/.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Geo-Information Systems	Term Paper	20 pages	100	45%	1-3
Introduction to Earth System Data					1-3

Module Achievements: None

4.1.17 Modeling and Analysis of Complex Systems

Module Name	Modeling and Analysis of Complex Systems
Module Code	2025-MDE-BIO-01
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DSSB-MSc 1 - 2025-DE-MSc 1 - 2025-DSSB-MSc 3 - 2025-DE-MSc 3 - 2025-DE-MSc 4
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Lecture	35
Practical exercises, private study incl. exam preparation	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Modeling and Analysis of Complex Systems	MDE-BIO-01	Lecture	5

Module Description

This is a hands-on module on the mathematical and computational modeling of various complex systems, covering diverse fields of the natural and social sciences. The module starts with an introduction to mathematical modeling. The elements of a model are presented and the steps to follow when constructing a model are reviewed, from formulating the question, determining the basic constituents of a model, and qualitatively and quantitatively describing the relevant system to analyzing the equations with various checks and balances. An introduction are provided on Python, the programming language constituting the main computational tool adopted in the module. To put into practice the theory on the basics of modelling and Python programming, a number of classical models in ecology are reviewed, coded, and numerically analyzed. This will build up the skills for developing models that describe different complex systems and the associated processes. In particular, different ial equation models are developed.

They describe:

(1) the dynamics of diseases such as HIV, (2) the microbial growth in batch and chemostat cultures, (3) the dynamics of plankton ecosystems in the oceanic mixed layer, and (4) examples of life acting as a regulating force at a planetary scale. In addition, the lecturer introduces Agent-Based Modelling techniques with applications to cultural segregation problems and spatially explicit predator-prey interactions.

Recommended Knowledge

- Analysis, Basic Calculus, and Linear Algebra

-Read the syllabus

Intended Learning Outcomes

No	Competence	ILO
1	Design	Independently design and develop models (from the basic conceptual aspects, to the mathematical equations and the numerical code) for tackling problems in the natural and social sciences.
2	Undertake	Undertake numerical equilibria and stability analysis, to evaluate model performance, and to identify uncertainties in model results.
3	Undertake	Undertake numerical equilibria and stability analysis, to evaluate model performance, and to identify uncertainties in model results.

Indicative Literature

- The course is based on a self-contained, detailed set of online lecture notes and practical exercises.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Modeling and Analysis of Complex Systems	Written Examination	120 minutes	100	45%	1-3

Module Achievements: None

4.1.18 Management and Analysis of Biological and Medical Data

Module Name	**Management and Analysis of Biological and Medical Data**
Module Code	2025-MDE-BIO-03
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 1 - 2025-DE-MSc 3
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Marc-Thorsten Hütt

Forms of Learning and Teaching	
Lectures and plenary discussions	20
Project Work	105
Workload Hours	125 hours

Module Components	**Number**	**Type**	**CP**
Management and Analysis of Biological and Medical Data	MDE-BIO-03	Seminar	5

Module Description

High-throughput technologies have turned biological and medical research into 'big data' endeavors. It is indispensable to be able to navigate the rich, intricate landscape of biological and medical databases and to contextualize and analyze information from diverse sources. Here we explore examples of recent databases in Biology and Medicine selected from the current database issue of the journal Nucleic Acids Research. Typical examples include databases for gene expression, metabolic systems, genome-wide association studies and epigenetic information.

In the first sessions of the course, we define small research projects based on the selected databases. In the rest of the course these research projects will be pursued in small groups and the results will be reported and discussed.

Intended Learning Outcomes

No	**Competence**	**ILO**
1	Identify	Identify and process a variety of data formats and data standards in biology and medicine.
2	Access	Access and use the main bioinformatics databases.
3	Download	Download and analyze diverse biological and medical data.
4	Derive	Derive research questions from scientific publications.
5	Apply	Apply concepts from data science to biological and medical databases.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Management and Analysis of Biological and Medical Data	Oral Examination		100	45%	1-5

Module Achievements: None

4.1.19 Data Mining

Module Name	Data Mining
Module Code	2025-MDE-BSC-01
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DSSB-MSc 2 - 2025-DE-MSc 2 - 2025-DSSB-MSc 4 - 2025-MBA-120-MA 2
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Adalbert F.X. Wilhelm

Forms of Learning and Teaching	
Lecture	17.5
Project Work	90
Independent Study	17.5
Workload Hours	125 hours

Module Components	Number	Type	CP
Data Mining	MDE-BSC-01	Lecture	5

Module Description

The focus of this module is on practical applications of algorithms and computational paradigms that allow computer-based search and detection of data patterns and regularities. Students learn how to use such tools to perform predictions and make forecasts. Students will study data mining as the core component in the knowledge discovery in database process which deals with extracting useful information from raw data. This knowledge discovery process includes data selection, cleaning, coding, using different statistical and machine learning techniques, and visualization of data and generated patterns and structures. The module aims tot provide an overview of all these issues and illustrates the whole process by examples.

A major component of the module is group-based participation in a data analysis competition. This competition allows students to apply the concepts learned in class and to develop the computational skills to analyze data in a collaborative setting.

Recommended Knowledge

- Knowledge of Data Analytics software/ programming languages such as R or Python.

- Practice data analysis tasks

- Read the Syllabus.

Usability and Relationship to other Modules

This module builds on the core module data analytics MDE-CO-02 and prepares students for applied projects in data analysis as well as a master thesis in this field.

Intended Learning Outcomes

No	Competence	ILO
1	Implement	Implement and apply advanced data mining methods with appropriate tools.
2	Evaluate	Evaluate and compare the suitability, scalability and efficiency of different methods in practical settings.
3	Have	Have gained experience in performing a full cycle of data mining and data analysis.
4	Have	Have acquired practical skills to tackle data mining problems.

Indicative Literature

- G. James, D. Witten, T. Hastie, R. Tibshiran, Introduction to Statistical Learning with R by Springer, 2013 (ISLR).
- J. VanderPlas, Python Data Science Handbook, 2016 - https://jakevdp.github.io/PythonDataScienceHandbook/.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Mining	Project Report	20 pages	100	45%	1-4

Module Achievements: None

4.1.20 Data Analytics in Supply Chain Management

Module Name	Data Analytics in Supply Chain Management
Module Code	2025-MSCM-CO-07
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 3 - 2025-SCM-MSc 3 - 2025-MBA-120-MA 3
Duration	1 Semester
Program Affiliation	2025-SCM-MSc (Supply Chain Management)
Module Coordinator(s)	Prof. Dr. Hendro Wicaksono

Forms of Learning and Teaching	
Lecture	35
Group Discussion	45
Independent Study	45
Workload Hours	125 hours

Module Components	Number	Type	CP
Data Analytics in Supply Chain Management	MSCM-CO-07	Lecture	5

Module Description

In recent years, big data has become a significant topic in supply chain management, as the amount of data generated in supply chain management practices has grown exponentially. Data analytics are techniques that apply data mining, statistical analysis, predictive analytics, and machine learning to uncover hidden patterns, correlations, trends, and other business-valuable information and knowledge from data.

The module focuses on the supply chain management scenarios that generate and consume data intensively and require data analytics to improve the decision-making process through descriptive, predictive, and prescriptive analytics. These include:

- Descriptive statistics on and historical insight into companies' production, financial, operations, sales, customers, etc.

- Forecasting customer behavior, purchasing patterns, production performance, energy consumption, etc.

- Prescriptive analytics for assessing the offer that should be made to a certain customer, to decide on the shipment strategy for each location, to determine the most efficient material flow in a factory, etc.

Recommended Knowledge

- Basics of statistical analytics and machine learning

- Basics of database and SQL

- Basics of programming skills, such as R, Python, and Java

- Sanders, N. Big data driven supply chain management: a framework for implementing analytics and turning information into intelligence, Pearson Education, 2014.

Usability and Relationship to other Modules

Programming methods, such as R and Python, taught in MSCM-MET-01 Programming in Python and MSCM-MET-03 Programming in R as well as project management concepts taught in MSCM-CO-01 will be applied. Academic writing skills taught in MSCM-CAR-01 facilitate the completion of tasks in this module.

Intended Learning Outcomes

No	Competence	ILO
1	Identify	Identify scenarios in supply chain management and evaluate the opportunities and challenges of data analytics applications.
2	Determine	Determine the objective of data analytics in different scenarios and the data sources required to achieve that objective.
3	Apply	Apply methods and tools to collect and integrate data from different sources in the context of supply chain management.
4	Apply	Apply machine learning and statistical analytics methods and tools to uncover hidden patterns, correlations, trends, and knowledge that are useful for improving supply chain management processes.
5	Evaluate	Evaluate data analytics results in different scenarios and solve the problems that might occur throughout the entire data analytics process, from data collection to analysis.
6	Develop	Develop deployment architecture concepts by integrating existing tools/software.
7	Develop	Develop business model and ecosystem concepts.

Entry Requirements

Prerequisites	Programming in Python Introduction to Data Management with Python
Co-requisites	None
Additional Remarks	

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Data Analytics in Supply Chain Management	Project Report	2500 words	100	45%	1-7

Module Achievements: None

4.1.21 Modeling and Control of Dynamical Systems

Module Name	**Modeling and Control of Dynamical Systems**
Module Code	2025-MDE-MET-04

Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 2 - 2025-DE-MSc 4
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	PD Dr. Mathias Bode

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	**Number**	**Type**	**CP**
Modeling and Control of Dynamical Systems	MDE-MET-04	Seminar	5

Module Description

Predictions based on the past, with or without additional input information? This is the topic of our module on dynamical systems. In many cases these forecasts are (almost) exact; in others we can only get probabilistic information. Based on a large set of examples, the module is going to discuss these so-called deterministic and stochastic systems. Topics we cover include:

- Deterministic low-dimensional dynamical systems.

- Control of deterministic linear systems.

- Linear prediction of stochastic time series.

Recommended Knowledge

- Basic linear algebra, calculus, probability concepts and programming skills as taught in introductory modules.

- Read the book: "Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering" by Steven H. Strogatz, in particular parts I+II. In order to prepare, please, read chapters 1,2+5.

Usability and Relationship to other Modules

Complementary to the machine Learning module MDE-CO-04 this module focuses on a theory-based design of models. Such models, if available, are usually “smaller” and easier to parameterize.

Intended Learning Outcomes

No	**Competence**	**ILO**
1	Understand	Understand and apply fundamental concepts of deterministic and stochastic dynamical systems.
2	Solve	Solve linear ordinary differential equations with constant coefficients.

3	Understand	Understand and apply fundamental concepts from linear control theory.
4	Understand	Understand and apply (conditional) means, variances, and covariances to predict the behavior of simple stochastic systems.

Indicative Literature

- S. H. Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering, 2nd edition, 2015.
- S. Zak, Systems and Control, Oxford University Press, 2003.
- H. Stark & J. Woods, Probability and Random Processes with Applications to Signal Processing, Westview Press, 2002.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Modeling and Control of Dynamical Systems	Written Examination	120 minutes	100	45%	1-4

Module Achievements: None

4.1.22 Text Analysis and Natural Language Processing

Module Name	Text Analysis and Natural Language Processing
Module Code	2025-MDSSB-MET-02
Module ECTS	5
Study Semester	Mandatory status for: 2025-DSSB-MSc 2 Mandatory Elective status for: - 2025-DE-MSc 2 - 2025-CSSE-MSc 2
Duration	1 Semester
Program Affiliation	2025-DSSB.MSc (Data Science for Society and Business)
Module Coordinator(s)	Prof. Dr. Hilke Brockmann/ Prof. Dr. Jan Lorenz / Prof. Dr. Adalbert F.X. Wilhelm

Forms of Learning and Teaching	
Seminar	17.5
Laboratory	17.5
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Text Analysis and Natural Language Processing	MDSSB-MET-02	Seminar	5

Module Description

This module will teach the fundamentals of text mining, natural language processing, and automated content analysis using R. Students will learn the entire text analysis pipeline, from basic web scraping techniques for collecting text data from social media, over text representations and ontologies, to text mining algorithms and efficient representation of analysis results. Students will be exposed to theoretical and methodological foundations of text mining, such as word frequencies, ontologies, bag-of-word, as well as the application of machine learning algorithms for text and sentiment analysis. The module will introduce exemplary studies on text and sentiment analysis and provide an opportunity for hands-on programming to realize different analyses. The module covers a spectrum of text mining methods, from basic lexicographic measures to more complex statistical learning algorithms such as sentiment analysis and topic modeling.

Recommended Knowledge

Programming skills in R or Python at an intermediate level

Usability and Relationship to other Modules

This module translates the insights from “Data Science Concepts” into text analysis. The module lays the basis for core and elective modules in semester 2 and 3, particularly for the “Digital Public Spheres,” “Data Science Lab,” “Data Analytics,” and “Cybercriminology” modules.

Intended Learning Outcomes

No	Competence	ILO
1	Explain	Explain the concept of “text as data”.
2	Use	Use basic methods for information extraction and text data retrieval.
3	Process	Process and prepare text data for statistical modeling and automated content analysis.
4	Perform	Perform different text analyses using text mining packages in R.
5	Interpret	Interpret diverse text analytical measures.
6	Undertake	Undertake a knowledgeable automated content analysis with text data.

Indicative Literature

- Silge, Robinson (2017) Text Mining with R: A Tidy Approach. Sebastopol, CA: O’Reilly.

Entry Requirements

Prerequisites	**None**
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration /Length	Weight (%)	Minimum	ILOs
Text Analysis and Natural Language Processing	Project Report	3000 words	100	45%	1-6

Module Achievements: None

4.1.23 Deep Learning

Module Name	Deep Learning
Module Code	2025-MCSSE-AI-01
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-PHDS-BSc 1 - 2025-PHDS-BSc 3 - 2025-AST-MSc 1 - 2025-DE-MSc 1 - 2025-SDT-BSc 1 - 2025-CSSE-MSc 1 - 2025-SDT-BSc 3 - 2025-CSSE-MSc 3 - 2025-DE-MSc 3
Duration	1 Semester
Program Affiliation	2025-CSSE-MSc (Computer Science & Software Engineering)
Module Coordinator(s)	Prof. Dr. Andreas Birk

Forms of Learning and Teaching	
Exam Preparation	20
Independent Study	70
Lecture	35
Workload Hours	125 hours

Module Components	Number	Type	CP
Deep Learning	MCSSE-AI-01	Lecture	5

Module Description

In machine learning we aim at extracting meaningful representations, patterns and regularities from high-dimensional data. In recent years, researchers from various disciplines have developed “deep” hierarchical models, i.e. models that consist of multiple layers of nonlinear processing. An important property of these models is that they can “learn” by reusing and combining intermediate concepts, so that these models can be used successfully in a variety of domains, including information retrieval, natural language processing, and visual object detection. After a brief introduction into core knowledge related to training, model evaluation and multilayer perceptrons, this module focuses on the exposing students to deep learning techniques including convolutional and recurrent neural networks, autoencoders, generative adversarial networks and reinforcement learning. The central aim is hence to enable students to critically assess and apply modern methods in machine learning.

Recommended Knowledge

- This module is recommended for students that have been exposed to core knowledge in machine learning / statistical learning on undergraduate level. Students without this background knowledge can

still join since required core knowledge is re-introduced. Preparation via auxiliary literature or online courses will facilitate the start into the course.

- Strong knowledge and abilities in mathematics (linear algebra, calculus).

Usability and Relationship to other Modules

While the graduate level modules "Data Analytics" and "Machine Learning" provide an applied introduction to the field and are therefore recommended for students with a focus on Software Engineering or Cybersecurity, this module complements the undergraduate module "Machine Learning" or can be used independently as a strong introduction to the field of Deep Learning.

Intended Learning Outcomes

No	Competence	ILO
1	Understand	Understand core techniques to train neural networks.
2	Select	Select from modern neural network architectures the most appropriate method (e.g. convolutional and recurrent neural networks) based on given input data.
3	Contrast	Contrast different recent unsupervised learning methods including autoencoders and generative adversarial networks.
4	Describe	Describe techniques in reinforcement learning.

Indicative Literature

- Ian Goodfellow, Yoshua Bengio, Aaron Courville: Deep Learning, MIT Press, 2016.
- Aurélien Géron: Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, 2nd Edition, O'Reilly, 2019.
- Christopher M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006.
- Charu C. Aggarwal: Neural Networks and Deep Learning – A Textbook, Springer, 2018.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Deep Learning	Written Examination	120 minutes	100	45%	1-4

Module Achievements: None.

4.1.24 Probabilities for Graduate Students

Module Name	Probabilities for Graduate Students
Module Code	2025-MDE-MET-02
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 1
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	PD Dr. Mathias Bode

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Probabilities for Graduate Students	MDE-MET-02	Lecture	5

Module Description

This module offers a highly structured introduction to the fundamentals of combinatorics and probabilities as they are used for statistical modeling and estimation. It is a gateway for graduate students who have not been exposed to the topics so far, or who were exposed long ago and needs to be refreshed. The module starts with the concept of probabilities, including joint, conditional and total probabilities with a focus on independence, which leads us to a discussion of Bayes's theorem. We shall then proceed to factorials, and binomial coefficients, with many applications to be followed by the binomial law, and its Poisson and Normal approximations. A second block covers random variables with their distributions and density functions. Here we are going to discuss continuous random variables in detail. Block three continues with the essential ideas of expected values, moments, and estimation.

Usability and Relationship to other Modules

Familiarity with probability-related concepts is the basis to understand the foundations of stochastic modelling and the data analytics and machine learning techniques which form a central part of data engineering. There is a placement test offered in the orientation week before the start of the first semester to help all students to find out if they need to take this remedial course.

Recommended Knowledge

Read the Syllabus.

Intended Learning Outcomes

No	Competence	ILO
1	Understand	Understand the fundamental concepts of probabilities and combinatorics and to apply them in structured situations.

2	Apply	Apply important probability laws (Binomial, Poisson, Normal).
3	Understand	Understand and apply probability distributions and densities.
4	Understand	Understand and apply means, variances, and covariances – also in the context of simple estimation contexts.

Indicative Literature

- H. Stark, J. W. Woods, Probability and Random Processes with Applications to Signal Processing, Third Edition, 2002.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Probabilities for Graduate Students	Written Examination	120 minutes	100	45%	1-4

Module Achievements: None

4.1.25 Calculus and Linear Algebra for Graduate Students

Module Name	Calculus and Linear Algebra for Graduate Students
Module Code	2025-MDE-MET-01
Module ECTS	5
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 1
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Igors Gorbovickis

Forms of Learning and Teaching	
Lecture	35
Independent Study	90
Workload Hours	125 hours

Module Components	Number	Type	CP
Calculus and Linear Algebra for Graduate Students	MDE-MET-01	Lecture	5

Module Description

This module offers a highly structured introduction to the fundamentals of two major pillars of mathematical modelling and analysis: Single and multivariable calculus on the one hand and linear algebra on the other.

It is a gateway for graduate students who have not been exposed to the topics so far, or who were exposed long ago and needs to be refreshed.

Topics include sequences, series, limits, derivatives, Taylor series, and integrals as well as vectors, matrices, determinants, eigenvalues, eigenvectors, scalar products, and norms. The module focuses on practical experience rather than on mathematical rigor.

Recommended Knowledge

- Mathematics at High School level

.- Read the Syllabus.

Usability and Relationship to other Modules

This module introduces and refreshes the essential Calculus and Linear Algebra required in most of the modules of the data engineering program. There is a placement test offered in the orientation week before the start of the first semester to help all students to find out if they need to take this remedial course.

Intended Learning Outcomes

No	Competence	ILO

1	Apply	Apply the fundamental concepts of calculus and linear algebra in structured situations.
2	Understand	Understand and use vectors and matrices, calculate determinants, eigenvalues and eigenvectors in simple cases.
3	Calculate	Calculate derivatives and simple integrals.
4	Explain	Explain the importance of the methods of calculus and linear algebra in problems arising from applications.
5	Understand	Understand the methods of calculus and linear algebra used in more advanced modules as well as in scientific literature.

Indicative Literature

- G. Strang, Introduction to Linear Algebra, 5th edition, Wellesley-Cambridge Press, 2016, ISBN: 978-09802327-7-6.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Calculus and Linear Algebra for Graduate Students	Written Examination	120 minutes	100	45%	1-5

Module Achievements: None

4.1.26 Current Topics in Data Engineering

Module Name	Current Topics in Data Engineering
Module Code	2025-MDE-DIS-01
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 1 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
	17.5
Independent Study	107.5
Workload Hours	125 hours

Module Components	Number	Type	CP
Current Topics in Data Engineering	MDE-DIS-01	Colloquium	5

Module Description

This module introduces current topics and challenges of data engineering. Lectures are taught by faculty members and invited experts from companies, presenting selected fields of their research activities and interest in data engineering. For each field an overview of the scientific background, the motivation and major challenges is provided together with a list of references. This is complemented by an in-depth discussion of the specific research topics. Each student will then select one field of the faculty presentations and will prepare a term paper in the form of a master thesis proposal, which will be presented as a poster at the end of the module. The module will additionally feature tutorials providing the students with scientific skills.

Usability and Relationship to other Modules

This module particularly prepares for the Advanced Project modules MDE-DIS-02 and MDE-DIS-03 and also gives the students an orientation with respect to which methods are required to master current developments in data engineering.

Recommended Knowledge

Read the Syllabus

Intended Learning Outcomes

No	Competence	ILO
1	Describe	Describe a current topic in Data Engineering.
2	Research	Research and read scientific literature.
3	Communicate	Communicate in scientific language using field specific-technical terms.

Indicative Literature

- The literature is provided by each instructor of the current topics lecture in the slides, which are provided immediately after each lecture to all students by pdf on a teamwork space created by the instructor of record Prof. Kettemann.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	**Examination Type**	**Duration/ Length**	**Weight (%)**	**Minimum**	**ILOs**
Current Topics in Data Engineering	Poster Presentation	120 minutes	100	45%	1-3

Module Achievements: None

4.1.27 Advanced Project 1

Module Name	Advanced Project 1
Module Code	2025-MDE-DIS-02
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 2 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Lecture	17.5
Seminar	35
Independent Study	72.5
Workload Hours	125 hours

Module Components	Number	Type	CP
Advanced Project 1	MDE-DIS-02	Lecture and Seminar	5

Module Description

This module aims to provide the student with an in-depth understanding and command of one of the data analytics or data management techniques that are represented by the research groups of the faculty of DE. The subdiscipline involved (e.g. database management, machine learning, statistical data analysis, information theory, data acquisition, or big data technologies) changes from year to year and from hosting group to hosting group. The detailed structure and schedule depend on the specific demands and options of the hosting group.

An Advanced Project module typically begins with an introduction to the concerned technology or method. This leads the student to a level of competence with which he/she can insightfully apply the respective methods to practical, real-life tasks. Typically, the second half of the module is devoted to individual (or if indicated, group) projects in which a nontrivial data management/ analysis task, given by the instructor, is completed. The project outcome is a technical report (target size: 20 pages) together as well as with a presentation to the Data Engineering program students and faculty.

Usability and Relationship to other Modules

The students can choose a project, ideally on a topic and with a supervisor they already encountered during the 1st semester module MDE-DIS-01 Current Topics in Data Engineering.

Recommended Knowledge

Read the syllabus

4.1.27.1 Intended Learning Outcomes

No	Competence	ILO

1	Understand	Understand current technical/scientific literature, and distinguish good from second-rate publications.
2	Write	Write / configure computer programs / tools specifically for the subject area.
3	Master	Master relevant data pre/ postprocessing routines specifically for the subject area.
4	Design	Design and schedule a complex DE project, including escape options, keep milestones/timelines.
5	Consistently	Consistently apply scientific language to communicate in writing his/her understanding clearly and precisely to a non-expert audience.

Indicative Literature

- The literature is provided individually to each student by each instructor of the respective advanced project.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Advanced Project 1	Project Report	20 pages	100	45%	1-5

Module Achievements: None

4.1.28 Advanced Project 2

Module Name	Advanced Project 2
Module Code	2025-MDE-DIS-03
Module ECTS	5
Study Semester	Mandatory status for: - 2025-DE-MSc 3 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Supervised Study, Research and Project Work	125
Workload Hours	125 hours

Module Components	Number	Type	CP
Advanced Project 2	MDE-DIS-03	Project	5

Module Description

This module aims to providing the student with an in-depth understanding and command of one of the data analytics or data management techniques that are represented by the research groups of the faculty of DE. The subdiscipline involved (e.g. database management, machine learning, statistical data analysis, information theory, data acquisition, or big data technologies) changes from year to year and from hosting group to hosting group. The detailed structure and schedule depend on the specific demands and options of the hosting group. An Advanced Project module typically begins with a taught introduction to the concerned technology or method. This will lead the student to a level of competence with which he/she can insightfully apply the respective methods to practical, real-life tasks. Typically, the second half of the module is devoted to individual (or if indicated, group) projects in which a nontrivial data management/analysis task, given by the instructor, is worked out. The project outcome is a technical report (target size: 20 pages) together with a presentation to the Data Engineering program students and faculty.

Recommended Knowledge

Read the syllabus

Usability and Relationship to other Modules

The students can build on the project they worked on in the module MDE-DIS-02 Advanced Project 1. However, they are also free to choose another project topic with a different supervisor.

Intended Learning Outcomes

No	Competence	ILO
1	Understand	Understand current technical/scientific literature, and distinguish good from second-rate publications.

2	Write	Write / configure computer programs / tools specifically for the subject area.
3	Master	Master relevant data pre/postprocessing routines specifically for the subject area.
4	Design	Design and schedule a complex DE project, including escape options, keep milestones/timelines.
5	Hone	Hone technical writing skills.
6	Communicate	Communicate technical results to a non-expert audience.

Indicative Literature

- The literature is provided individually to each student by each instructor for the respective advanced project.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Advanced Project 2	Project Report	20 pages	100	45%	1-6

Module Achievements: None

4.1.29 Internship DE

Module Name	Internship DE
Module Code	2025-MDE-INT-01
Module ECTS	10
Study Semester	Mandatory status for: None Mandatory Elective status for: - 2025-DE-MSc 2 - 2025-DE-MSc 3
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Internship	231
Project Work	19
Workload Hours	250 hours

Module Components	Number	Type	CP
Internship DE	MDE-INT-01	Internship	10

Module Description

Students can work on an internship in a company, government institution, or non-governmental organization to gain practical experience and to apply their knowledge and skills in data engineering in practice. A minimum of 231 working hours (corresponding to 6 weeks of full-time occupation, which can also be done part time stretched over a longer period starting from the 2nd semester) is required for the successful completion of this module, which then can replace two advanced projects of 5CP each. This gives students the opportunity to train, foster, and apply their acquired skills in data engineering in a professional setting. Students engage with the corporate world, learn how to cope and excel in a new environment. The internship content must be relevant to data engineering. Task specifications need to be appropriate for a master's level student. The module coordinator, the student advisor and the Career Service Center will support students in finding suitable positions. The student needs to find a faculty member at Constructor University who agrees to be the academic supervisor prior to starting the internship. The module coordinator then decides on the eligibility of the internship to replace two advanced projects of 5CP each, prior to the start of the internship.

The internship provides training and experiential learning opportunities for data engineering in a professional setting. It assists the students' development of employer-valued skills, such as teamwork, communication, steadiness, and attention to detail. It exposes the students to the environment and performance expectations in the corporate world, may help prepare an application-oriented master thesis, and may make the entry into the professional job market easier.

Recommended Knowledge

Consider the internships offered and presented by companies in the module Current topics in Data Engineering. Consult with Career Services, the study program chair and/or your academic advisor on more options for internships and send applications.

Usability and Relationship to other Modules

An internship with at least 6 weeks of full-time occupation, or part time, stretched over a correspondingly longer period, where data engineering skills are applied can replace two advanced project modules of 5CP each.

Intended Learning Outcomes

No	Competence	ILO
1	Apply	Apply data engineering concepts and tools in a real-world setting.
2	Demonstrate	Demonstrate professional work attitude and business etiquettes
3	Collaborate	Collaborate effectively in a professional environment.
4	Demonstrate	Demonstrate a solid work ethic and professional demeanor.
5	Demonstrate	Demonstrate commitment to ethical conduct and legal regulations.
6	Improve	Improve reporting and writing skills.
7	Communicate	Communicate results to a non-expert audience.

Indicative Literature

- The literature is provided individually to each student by each instructor for the respective internship.

Entry Requirements

Prerequisites	Current Topics in Data Engineering
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Internship DE	Project Report	30 pages	100	45%	1-7

Module Achievements: None

4.1.30 Master Thesis DE

Module Name	Master Thesis DE
Module Code	2025-MDE-THE-01
Module ECTS	30
Study Semester	Mandatory status for: - 2025-DE-MSc 4 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Independent Study	750
Workload Hours	750 hours

Module Components	Number	Type	CP
Master Thesis	MDE-THE-01	Thesis	30
Master Thesis	MDE-THE-01		

Module Description

The aim of this module is to train students to motivate, design, carry out and document a research project in one of the areas represented by the research groups of the faculty of DE. Some familiarity with the requisite data engineering techniques will typically have been acquired in one of the preceding Advanced Projects (MDE-DIS-02 or MDE-DIS-03). The thesis topic is determined in mutual agreement with the module instructor. They may arise from the ongoing research in the instructor's own research group, but it is also possible for a student to adopt a topic of his/her own choice provided the instructor agrees to supervise it.

The thesis work comprises the full cycle of a scientific research endeavor: (i) identifying a relevant open research question, (ii) carrying out a literature survey to put the planned work in its context and relate it to the state of the art (SoA), (iii) formulate a concrete research objective, (iv) design a research plan including a statement of criteria to evaluate the success of the project, (v) carry out the plan (with the possibility to change the original plan when motivated), (vi) document the results, (vii) analyze the results with respect to the SoA, the original objective, and the success criteria, and (viii) document all of this in a thesis report.

All of this work should be done with as much self-guidance as can be reasonably expected. The instructor will likely give substantial guidance for (i) and (iii), whereas the other aspects will be addressed with larger degrees of self-guidance. A research proposal document summarizing (i) – (iv) is expected as an interim result and milestone (target size: 10 pages). In the first weeks of the course, an intense taught tutorial on scientific working and writing is held. The subsequent weeks follow a seminar style where students present and discuss literature as well as their own results to date. The project consists of the proposal, a thesis report (target size: 30–60 pages, and an oral presentation at the end of the course.

Usability and Relationship to other Modules

The master thesis can build on the advanced project courses MDE-DIS-02 Advanced Project 1 and MDE-DIS-03 Advanced Project 2 but the students are free to choose a different topic and a different supervisor for the master thesis.

Recommended Knowledge

- Read the Syllabus

- Proficiency in the area of the chosen thesis topic.

Intended Learning Outcomes

No	Competence	ILO
1	Understanding	Understanding, at a professional level, of a circumscribed segment of the hosting group's research area.
2	Ability	Ability to apply specific and selected DE techniques, as required for the project, at a professional level.
3	General	General professional skills.
4	Designing	Designing and carrying out the full cycle of a scientific research project in a professional manner.
5	Formulating	Formulating a research proposal such that that it could serve as a funding proposal.
6	Writing	Writing a research thesis such that it could be submitted to a scientific publication venue, or as a project report to a funding agency or industrial client.
7	Presentation	Presentation of project results for specialists and non-specialists.

Entry Requirements

Prerequisites	Advanced Project 1 Advanced Project 2
Co-requisites	None
Additional Remarks	

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Master Thesis	Thesis	30-60 pages	75	45%	1-7
Master Thesis	Oral Examination	20 minutes (Defense)	25	45%	All, Mainly presentation of project results learning outcomes

Module Achievements: None

4.1.31 Communication & Presentation Skills for Executives

Module Name	Communication & Presentation Skills for Executives
Module Code	2025-MDE-CAR-01
Module ECTS	2.5
Study Semester	Mandatory status for: - 2025-DSSB-MSc 1 - 2025-CSSE-MSc 1 - 2025-DE-MSc 1 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-MBA-120-MA (MBA 120)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Seminar	17.5
Independent Study	45
Workload Hours	62.5 hours

Module Components	Number	Type	CP
Communication & Presentation Skills for Executives	MDE-CAR-01	Seminar	2.5

Module Description

An executive career in an international business environment requires excellent communication and presentation skills. Managers have to communicate effectively with a large variety of target audiences, often in different languages and with different cultural backgrounds. This is true for employees and/or direct reports, business partners as well as customers. The ability to present and communicate succinctly and confidently while being culturally aware and building rapport and trust with different audiences is crucial. In this interactive module, students are introduced to the basics of effective presentation and communication techniques. They learn how to present themselves, their business project, or academic work, with impact, tailoring both the content and their delivery style to different types of audiences.

Recommended Knowledge

- Analysis, Basic Calculus, and Linear Algebra

- Read the Syllabus

Usability and Relationship to other Modules

This module is recommended to be taken together with the elective modules in the Bio-Informatics track.

Intended Learning Outcomes

No	Competence	ILO

1	Act	Act as effective communicators – in both group and individual situations.
2	Understand	Understand interpersonal communication models and group dynamics in presentations.
3	Enjoy	Enjoy the process of presenting.
4	Understand	Understand the importance of building rapport and trust with audiences.
5	Use	Use presentation software (PowerPoint, Prezi) confidently and in a visually pleasant way.
6	Learn	Learn how to structure presentations in a coherent manner and develop captivating narratives.
7	Work	Work with different presentation formats (Ignite, Pecha Kucha, Pitching etc.).
8	Understand	Understand and apply the basics of logical reasoning in oratory (deductive/inductive).
9	Develop	Develop oratory and rhetorical skills drawing on Aristotle's teaching of logos, ethos and pathos.
10	Understand	Understand and apply the basics of interpersonal communication (Johari Window, 4-Ears model etc.).
11	Give	Give and receive constructive feedback.
12	Present	Present themselves in different business situations.
13	Collaborate	Collaborate effective in intercultural teams.

Indicative Literature

- This course utilizes lecture formats, case studies and interactive presentations, discussions, role play and peer-to-peer coaching. The course will also use internet resources, videos, and home assignments to illustrate and practice specific communication aspects.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Communication & Presentation Skills for Executives	Presentation	15 minutes	100	45%	1-13

Module Achievements: None

4.1.32 Academic Writing Skills/Intercultural Training

Module Name	Academic Writing Skills/Intercultural Training
Module Code	2025-MDE-CAR-02
Module ECTS	2.5
Study Semester	Mandatory status for: - 2025-CSSE-MSc 2 - 2025-DE-MSc 2 Mandatory Elective status for: None
Duration	1 Semester
Program Affiliation	2025-DE-MSc (Data Engineering)
Module Coordinator(s)	Prof. Dr. Stefan Kettemann

Forms of Learning and Teaching	
Lecture	17.5
Independent Study	45
Workload Hours	62.5 hours

Module Components	Number	Type	CP
Academic Writing Skills/Intercultural Training	MDE-CAR-02	Seminar	2.5

Module Description

The academically rigorous nature of graduate studies requires students to master academic writing skills and techniques. In this introductory course, students in DE master's program will learn the foundations of academic writing at a graduate level, with special focus on writing academic essays, identifying organizational patterns of academic texts, and formulating arguments to produce cohesive and coherent academic papers. Through the process of drafting, continuous feedback and editing, students will improve their writing skills. This course will also help students develop their research skills by highlighting techniques of finding and evaluating sources, and utilizing citation and referencing styles. As graduate students, adhering to The Code of Academic Integrity is a requirement. Hence, this course will incorporate a session on scholarly and intellectual standards set by Constructor University. The second part of this course is a training seminar. It will give answers to frequently asked questions by students on the topics of working and living in Germany. Here the students will find information on employment and how to get access to the German labor market. The seminar also provides an overview of labor conditions in Germany, the multifaceted forms of employment, business cultures and useful tips and information for the job entry in a German company.

Recommended Knowledge

- Read the Syllabus.

- Fraedrich, J. & Ferrell, O.C. (2014): Business Ethics: Ethical Decision Making & Cases. Cengage Learning.

Usability and Relationship to other Modules

For DE: Advanced Project 1, Advanced Project 2, Master thesis

Intended Learning Outcomes

No	Competence	ILO
1	Structure	Structure their ideas to write clear summaries, coherent paragraphs and cohesive literature reviews.
2	Write	Write different segments of an academic paper employing writing styles that display advanced grammar and precise and concise language use.
3	Successfully	Successfully find and evaluate sources for research.
4	Use	Use citation and referencing styles applicable for their discipline.
5	Avoid	Avoid unintentional plagiarism and adhere to the code of academic integrity.
6	Understand	Understand labor conditions in Germany.
7	Understand	Understand the typical business cultures in German companies.

Indicative Literature

For DE: The literature is provided individually to each student by each instructor for the respective advanced project.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Academic Writing Skills/Intercultural Training	Term Paper	10 pages	100	45%	1-7

Module Achievements: None

4.1.33 Ethics and the Information Revolution

Module Name	Ethics and the Information Revolution
Module Code	2025-MDSSB-EIR-01
Module ECTS	2.5
Study Semester	Mandatory status for: - 2025-DE-MSc 3 Mandatory Elective status for: - 2025-DSSB-MSc 3
Duration	1 Semester
Program Affiliation	2025-DSSB-MSc (Data Science for Society and Business)
Module Coordinator(s)	Prof. Dr. Hilke Brockmann

Forms of Learning and Teaching	
Seminar	17.5
Independent Study	45
Workload Hours	62.5 hours

Module Components	Number	Type	CP
Ethics and the Information Revolution	MDSSB-EIR-01	Seminar	2.5

Module Description

Many data specialists claim that we are at the cusp of an information revolution. Based on inventions dating back to WWII, IT innovations have re-organized our society around one "big metadata computer" that is permanently computing data and associating metadata about everything we do. Digital technologies also have the potential to disrupt the ethical standards and rules of our society. In this module, we discuss whether we have to forfeit privacy in times of big data, if machines compromise our identity, and if shared data enables institutions to abuse their power and undermine the civil society?

The module pursues three goals. 1. Participants will immerse themselves and learn about core ethical theories. 2. They will integrate this theoretical knowledge and develop a "Big Data Ethics," which they 3. will put into practice. For the second and third purposes, in-classroom discussions and interactions are indispensable for identifying possible dilemmas and conflict of interests and for balancing contradictions to derive practical solutions and policy advice.

Recommended Knowledge

- Read the Syllabus

- Binns (2018) Fairness in Machine Learning: Lessons from Political Philosophy. Proceedings of Machine Learning Research 81:1-11.

Usability and Relationship to other Modules

It is one of the three Career modules (IT Law, Language III, and Ethics and the Information Revolution) that can be chosen for replacement by the internship. Students need to replace 10 CP for the internship.

Intended Learning Outcomes

No	Competence	ILO
1	Report	Report on major ethical theories relevant to digital technologies.
2	Integrate	Integrate different ethical standpoints and arguments to address concrete societal problems.
3	Assess	Assess the societal and ethical implications of digitization.
4	Deal	Deal with legal aspects of ethics by applying means to prevent and deal with violations of privacy and transparency.
5	Apply	Apply actions to contribute to the transition to a more just and trustworthy digital transformation as a part of one's job.
6	Implement	Implement justice and social equality as dimensions of ethics and sustainability.

Indicative Literature

- Binns (2018) Fairness in Machine Learning: Lessons from Political Philosophy. Proceedings of Machine Learning Research 81:1-11.

Entry Requirements

Prerequisites	None
Co-requisites	None
Additional Remarks	None

Assessment and Completion

Components	Examination Type	Duration/ Length	Weight (%)	Minimum	ILOs
Ethics and the Information Revolution	Term Paper	20 pages	100	45%	1-6

Module Achievements: None

4.1.1 Language Skills

The description of the language module is provided in a separate document, the “Language Module Handbook” that can be accessed from here: https://constructor.university/student-life/language-community-center/learning-languages

5 Modules

5.1 Intended Learning Outcomes Assessment-Matrix

Data Engineering (M.Sc.)					Big Data Challenge	IT Law	Data Security and Privacy	Data Analytics	Data Management and Databases	Python Programming for Data Engineering	Cloud Computing	Data Pipeline Engineering	Machine Learning	Data Warehousing: Concepts and Technologies	Image Processing for Data	Data Acquisition Technologies and Sensor Networks	Modeling	Network Theory	Advanced Data bases	Geoinformatics	Management and Analysis of Biological and Medical Data	Data Mining	Data Analytics in Supply Chain Management	Modeling and Control of Dynamical Systems	Calculus and Linear Algebra for Graduate Students	Current Topics in Data Engineering	AdvProj1	AdvProj2	Internship DE	Master Thesis	German	Communication & Presentation Skills I. Ex.	Ethics and the Information Revolution	Academic Writing Skills/Intercultural Training
Semester					1	2	3	1	1	1	2	2	2	3	3	3	2	1 or 3	2	1 or 3	1 or 3	2	3	2	1	1	2	3	2 and 3	4	1	1	3	2
Mandatory/ Mandtory elective					me	m	m	m	m	m	m	m	me	m	m	me	me	me	me	me	me	me	me	me	me	m	m	m	m	m	m	m	m	m
Credits					5	2.5	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	10	30	5	5	5	2.5
Competencies*																																	
Program Learning Outcomes	**A**	**E**	**P**	**S**																													
critically assess and creatively apply technological possibilities and innovations driven by big data	x	x			x	x	x	x	x	x	x	x		x		x	x	x	x	x	x	x	x			x	x	x	x		x	x	
set up and use databases to efficiently and securely manage and access large amounts of data	x	x			x			x	x	x	x	x		x		x		x	x		x	x	x				x	x	x	x				
apply statistical concepts and use statistical models in the context of real-life data analytics	x	x						x					x				x	x		x	x	x	x	x			x	x	x	x				
use, adapt and improve visualization techniques to support data-based decision making	x	x			x				x	x					x	x		x		x							x	x	x	x				
Understand cloud computing concepts, use major cloud platforms and implement cloud solutions	x	x			x				x	x	x	x							x			x	x				x	x	x	x				
Understand data pipeline concepts, and build and manage data pipelines	x	x			x					x		x							x								x	x	x	x				
Understand the concepts of data warehousing and apply its tools, such as online analytical processing (OLAP), data	x	x			x				x			x		x					x								x	x	x	x				
design, implement and exploit various representations of data for classification and regression including supervised machine learning methods and core ideas of deep learning	x	x			x			x					x		x		x	x	x	x			x				x	x	x	x				
apply and critically assess data acquisition methods and analytical techniques in real life situations, organizations and industries	x	x		x	x		x	x	x	x		x	x	x	x	x		x		x			x	x		x		x	x	x	x				
independently investigate complex problems and undertake scientific or applied research into a specialist area utilizing appropriate methods, also taking methods and insights of other disciplines	x	x		x			x		x	x	x	x	x	x				x		x			x	x		x	x	x	x	x	x				
professionally communicate their conclusions and recommendations, the underlying information and their reasons to specialists and non-specialists both clearly and unambiguously on the basis of	x	x	x	x	x	x			x					x						x	x	x	x			x	x	x	x	x		x	x	x
assess and communicate social, scientific and ethical insights that also derive from the application of their knowledge and their decisions		x	x	x	x	x												x		x	x		x			x	x	x	x	x		x	x	x
engage ethically with academic, professional and wider communities and actively contribute to a sustainable future			x	x		x																				x	x	x	x	x		x	x	x
take responsibility for their own learning, personal development and role in society, evaluating critical feedback and self-analysis			x	x		x														x	x		x			x	x	x	x	x		x	x	x
take on lead responsibility in a diverse team		x	x		x	x				x									x							x	x	x	x	x				
adhere to and defend ethical, scientific and professional standards	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Assessment Type																																			
Written Examination							x		x	x	x	x		x	x			x	x					x	x										
Term paper						x														x													x	x	
Essay																																			
Project Report					x			x					x			x	x					x	x				x	x	x						
Poster presentation																										x									
Laboratory Report																			x																
Program code																																			
Oral Examination																					x														
Presentation																																x			
Practical Assessment									x	x	x	x																							
Project Assessment																																			
Portfolio Assessment																																			
Thesis																														x					
Various																															x				
Module achievements																																			

*Competencies: A-scientific/academic proficiency; E-competence for qualified employment; P-development of personality; S-competence for engagement in society