Master of Science (M.Sc.)

“Mannheim Master in Data Science”

University of Mannheim

– Module catalog –

for students starting before autumn 2024

Academic Year
HWS 2025/ FSS 2026

Contents

Foreword

This document describes the courses that will be offered in HWS 2025/ FSS 2026 for students studying M. Sc. Mannheim Master in Data Science (Examination Regulations for the Master's program from 10th December 2019). You can find the Examination Regulations on the website of the Student Services (Studienbüros):

https://www.uni-mannheim.de/en/academics/during-your-studies/examinations/examination-regulations/

It is possible that additional courses will be made available during the course of the academic year. These will be published in an appendix available on the following web page:

https://www.wim.uni-mannheim.de/en/academics/organizing-your-studies/mannheim-master-in-data-science/#c112237

A. Overview

		ECTS
Fundamentals	"Fundamentals" courses with at most 14 ECTS	0 – 14
Data Management	Minimum of three "Data Management" courses	18 – 36
Data Analytics Methods	Minimum of four "Data Analytics Methods" courses	30 – 54
Responsible Data Science	Minimum of one "Responsible Data Science" course	3 – 10
Projects and Seminars	Team Project **or** Individual Project, Scientific Research and Seminars	14 – 18
Master Thesis	Six-months-long written academic assignment	30
Total		120

General constraints:

1. Fundamental courses with 0-14 ECTS can be taken (0 to 14 ECTS)
2. 3 to 6 Data Management courses must be taken (18 to 36 ECTS)
3. Data Analytics Methods courses worth a combined 30 to 54 ECTS must be taken
4. 1 to 2 Responsible Data Science courses must be taken (3 to 10 ECTS)
5. You must either take a Team Project course or an Individual Project course
6. You must take Scientific Research
7. You must take a Seminar
8. You must write a Master Thesis

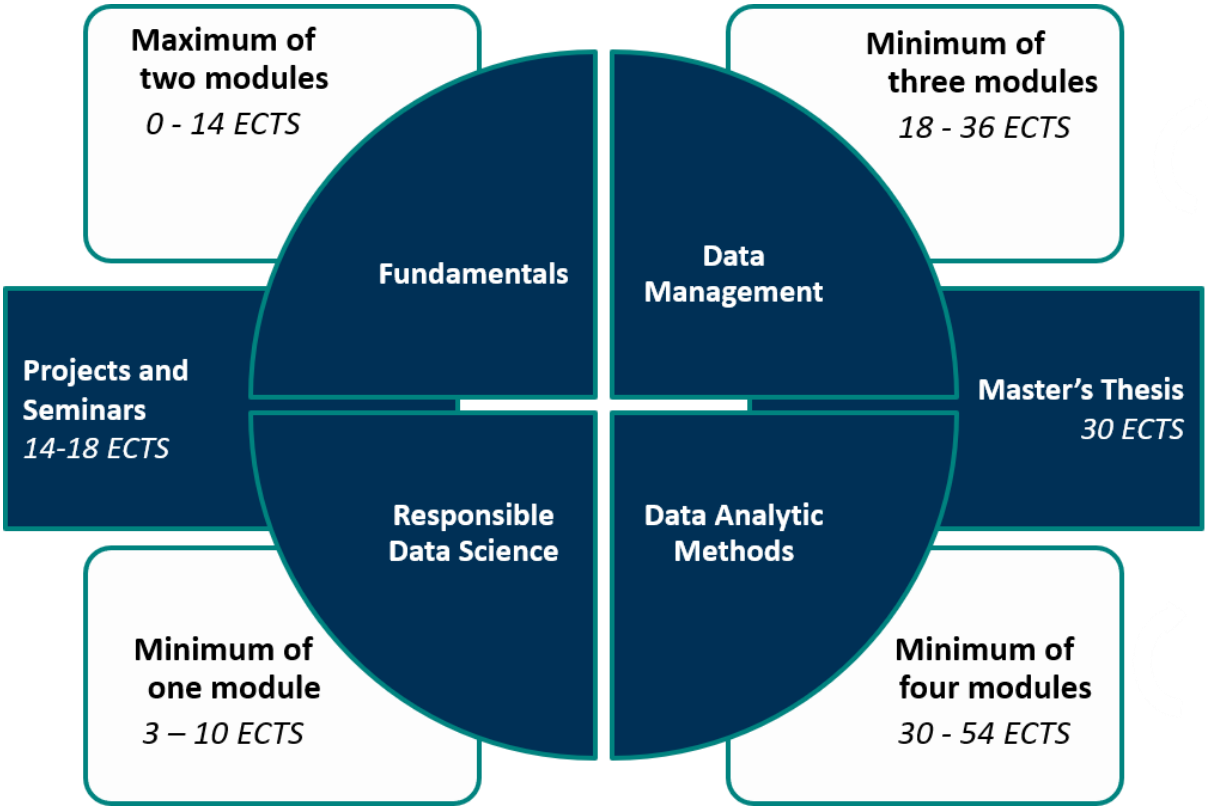
Abbreviations:

HWS (Herbst-/Wintersemester): Course is offered in the respective Fall semester.

FSS (Frühjahrs-/Sommersemester): Course is offered in the respective Spring semester.

FSS/HWS: course is offered both in Spring semester and Fall semester.

Course Structure



B. Fundamentals

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
CS 460	Databases for Data Scientists	FSS	E	6	7
IS 557	Scientific Programming with Python**	HWS	E	6	MMM*
DS 100	Statistics for Data Scientists	HWS	E	8	9

* For a detailed description, please see the module catalogues of the respective following degree programs:

- MMM: M.Sc. Mannheim Master in Management
  https://www.bwl.uni-mannheim.de/en/module-catalog-mmm/

**Prerequisites: No completed exam in CS 470 Programming with Python

2. Detailed descriptions

CS 460	**Databases for Data Scientists**
Form of module	Lecture with Exercise
Type of module	Foundations of Data Science (MMSDS) Fundamental (MMDS for students who started before 2024)
Level	Master
ECTS	6
Workload	Hours per semester present: 56 h (4 SWS)
	Self-study per semester: 98 h • 70 h: pre and post lecture studying and revision • 28 h: examination preparation
Prerequisites	-
Aim of module	The course provides an introduction to data storage and database systems. The course will cover the following topics: • Principles of data storage • Relational modelling • Query languages for relational databases (SQL) • Keys and normal forms • Hash and index structures • Concurrency • Databases for non-relational data • Principles of data integration
Learning outcomes and qualification goals	<u>Expertise:</u> Basic understanding of data storage, relational data modelling and database design, as well as the functionality of relational database management systems, query handling, and transaction management. Handling non-relational data. (MK1, MK 2, MK3)
	<u>Methodological competence:</u> Abstraction, modelling, complexity consideration. (MF1, MF2)
	<u>Personal competence:</u> Understanding the role of data management in enterprises. (MK01, MK02)
Media	Electronic slides and exercise sheets
Literature	Avi Silberschatz, Henry F. Korth, S. Sudarshan: Database System Concepts

Methods	The course consists of a lecture together and exercises. The exercises encompass both theoretical exercises as well as practical assignments, which are conducted with a free modern database management system and allow the students to deepen their theoretical understanding of the course contents, as well as to gather hands-on experience with database management systems.
Form of assessment	Written or oral examination
Admission requirements for assessment	-
Duration of assessment	60 minutes (written exam)/30 minutes (oral exam)
Language	English
Offering	Spring semester
Lecturer	Dr. Sven Hertling
Person in charge	Prof. Dr. Heiko Paulheim; Dr. Sven Hertling
Duration of module	1 semester
Further modules	Database Systems II, Large Scale Data Management, Web Data Integration
Range of application	MMSDS, MMDS (for students who started before HWS 2024)
Semester	1st/2nd semester

DS 100	**Statistics for Data Scientists**
Form of module	Lecture and Tutorial
Type of module	Foundations of Data Science
Level	Master
ECTS	9 (270 hours)
Workload	Hours per semester present: 56 h (4 SWS)
	Self-study: 214 h per semester • 91 h: pre and post lecture/tutorial studying and revision • 42 h: studying for and taking weekly online tests • 40 h: examination preparation • 41 h: preparation and presentation of weekly exercises
Prerequisites	A sound introduction of the linear regression model (OLS) is required. Knowledge in linear algebra and calculus is useful. This is the first in a two-course sequence covering statistical models and causal inference, continuing into Data Science 201 next semester. The topics in both courses will be integrated through the year. It is expected that students will take both semesters.
Aim of module	The course provides an introduction to the basics of regression models, including • The theoretical development of linear regression • Extensions to generalized linear models • Extensions to machine learning and model selection • Regular practice on applied data analysis
Learning outcomes and qualification goals	<u>Expertise:</u> Understand how to appropriately translate research question into statistical models, be able to apply statistical models appropriate for non-linear problems and learn how to present and interpret estimation results in a substantive meaningful way. (MK1, MK3)
	<u>Methodological competence:</u> Estimate regression parameters using the maximum likelihood principle; Perform hypothesis tests for regression models using the maximum likelihood principle; Be able to identify violations of the respective regression assumptions of the discussed GLMs; Be able to identify limitations of non-linear regression models. (MK1, MK3)
	<u>Personal competence:</u>

	The course supports students to develop competences with regard to choosing the appropriate statistical method(s) to answer respective research questions and how to present and communicate statistical results. (MF1, MF2, MF3, MKO1, MKO2)
Media	Lecture slides available online, exercises available online
Literature	• Verbeek, M. 2017. A Guide to Modern Econometrics. 5th ed. Chichester: Wiley. • Hansen, Bruce E. 2022. *Econometrics*. Princeton: Princeton University Press. • Angrist, Joshua D., and Jörn-Steffen Pischke. 2009. Mostly Harmless Econometrics: An Empiricist's Companion. Princeton: Princeton University Press. • Wooldridge, J.M. 2002. Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: MIT Press.
Methods	Lecture elements, weekly tests, literature studies
Form of assessment	Written examination
Admission requirements for assessment	Oral participation, homework, presentations, compulsory attendance
Duration of assessment	90 Minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Marc Ratkovic
Person in charge	Prof. Dr. Marc Ratkovic
Duration of module	1 semester
Further modules	
Range of application	MMSDS
Semester	1st semester

C. Data Management

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
AC 651	Additional Course – Data Management	HWS/FSS	E	Max. 18	12
CS 500	Advanced Software Engineering	HWS	E	6	13
CS 550	Algorithmics	FSS	E	6	15
CS 560	Large Scale Data Management	HWS	E	6	17
CS 600	Model-driven Development	HWS	E	6	19
CS 605**	Foundations of Artificial Intelligence: Search and Problem Solving	HWS	E	6	21
CS 630**	Generative Software Engineering	FSS	E	6	21
CS 651**	Cryptography II	HWS	E	6	25
CS 655**	Cryptography not offered in FSS 26	FSS	E	6	27
CS 664**	Blockchain Security	HWS	E	6	29
IE 650	Knowledge Graphs	HWS	E	6	31
IE 663	Information Retrieval and Web Search	HWS	E	3	33
IE 670	Web Data Integration	HWS	E	3	35
IE 683	Web Data Integration Project	HWS	E	3	37
IE 691	Information Retrieval Project	HWS	E	3	39
IS 540**	Management of Enterprise Systems	HWS	E	6	MMM*
IS 556**	Public Blockchains	FSS	E	6	MMM*
DS 200**	Sampling and Data	HWS	E	9	41
MAC 570**	Reinforcement Learning-Coding	Irreg.	E	8	43

* For a detailed description, please see the module catalogue of the respective following degree programs:

- MMM: M.Sc. Mannheim Master in Management, https://www.bwl.uni-mannheim.de/en/module-catalog-mmm/

**Additional offer to the Examination Regulations.

2. Detailed descriptions

AC 651	**Additional Course – Data Management**
Form of module	Depends on course
Level	Master
ECTS	Max. 18
Workload	Depends on course
Prerequisites	Depends on course
Aim of module	The course falls into the data management area of the MMDS and covers topics related to data management but is not directly equivalent to any course in the MMDS module catalogue. The course level equals a regular course in MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.
Learning outcomes and qualification goals	Depends on course
Media / Literature / Methods / Form and duration of assessment	Depends on course
Language	English preferred, but any other language possible if Mannheim faculty member is able to identify content and level
Offering	Spring semester / Fall semester
Lecturer	Lecturer at the host university
Person in charge	Lecturer at the host university
Duration of module	1 Semester
Further modules	-
Range of application	MMDS
Semester	$2^{nd}/3^{rd}/4^{th}$ semester

CS 500	**Advanced Software Engineering (Software Testing and Experimentation)**
Form of module	Lectures, exercises and tutorials
Type of module	Computer Science Fundamental
Level	Master
ECTS	6
Workload	Hours per semester present: 56 h (2 + 2 SWS)
	Self-study: 112 h per semester • 28 h per semester for preparation and studying of lectures/tutorials • 84 h per semester for the preparation of the exams
Prerequisites	Knowledge of Java and/or Python
Aim of module	The course introduces the fundamental concepts and practices of software testing, and software experimentation / evaluation • Principles of Testing • Test Coverage Criteria • Test specification techniques • Model-based testing • Principles of Experimentation • Use of Software Observatoriums
Learning outcomes and qualification goals	<u>Expertise:</u> Students will be familiar with principles, approaches and tools for testing software and the methods and empirically evaluating software products, methods and tools (MK1, MK2)
	<u>Methodological competence:</u> Students will have the ability to judge, select, and apply traditional or non-traditional test tools and techniques to evaluate software quality, as well as to design and perform software experiments. (MF1) (MF1, MF3)
	<u>Personal competence:</u> Students will have improved skills in analytical thinking and applying theoretical knowledge to solve practical problems, especially in software testing and experimentation. (MKO3)
Media	Lecture notes, presentations, tool demonstrations, software, data sets
Literature	Paul Ammann & Jeff Offutt., “Introduction to Software Testing”, Cambridge University Press, January 2008.
Methods	Lectures, weekly exercises, experimentation with different systems
Form of assessment	Written examination

Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Dr. Marcus Kessel, Prof. Dr. Colin Atkinson
Person in charge	Prof. Dr. Colin Atkinson
Duration of module	1 Semester
Further modules	Model-Driven Development, Generative Software Engineering
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1st or 2nd semester

CS 550	**Algorithmics**
Form of module	Lecture with tutorials
Type of module	Fundamental in Computer Science
Level	Master
ECTS	6
Workload	Attendance: 56 h per semester (4 h per week)
	Self-study: 112 h per semester • 28 h per semester for preparation and reworking of lectures/tutorials • 84 h per semester for the preparation of the exams
Prerequisites	Practical Informatics I, Algorithms and Data Structures, Linear Algebra, Statistics
Aim of module	The lecture deals with the design and the analysis of algorithms for various practically relevant computational problems and with methods for analyzing the complexity of certain problems. In particular, we will learn methods of formalizing discrete optimization problems and designing algorithms for them on the basis of analyzing the structure of these problems. Moreover, we will learn techniques for proving the correctness and estimating the running time of these algorithms. In the second part of the lecture, we will deal with the theory of NP-completeness with gives evidence that certain highly relevant problems do not have efficient algorithms. During the lecture we will derive algorithms and complexity-theoretic results for the following computational problems: • shortest path problems and shortest round tour problems • linear optimization problems • flow problem • matching problems • satisfiability problems • discreet linear optimization problems
Learning outcomes and qualification goals	<u>Professional expertise:</u> The students know efficient algorithms and the most important complexity-theoretic results for a number of computational problems which are highly relevant in practice. (MK1, MK2)
	<u>Methodological competence:</u>

	The students learn to formalize informally specified computational problems, to analyse their structure with the goal to design efficient algorithms, to prove the correctness and to analyse the running time of given algorithms. Moreover, they learn to prove the NP-completeness of certain problems. (MF1, MF3)
	<u>Personal competence:</u> Training of analytical, focussed, and precise thinking. Further development of abstraction abilities and the ability to transfer theoretical knowledge for solving practical problems, especially in the field of operations research. Increasing the sensitivity for the complexity and the efficient solvability of computational problems, especially through dealing with the theory of NP-completeness. (MF1, MKO3)
Media	Lectures Slides and Exercises
Literature	• Cormen, Leiserson, Rivest, Stein: Introduction to Algorithms, 3rd edition • Shimon Even: Graph Algorithms • Lovasz, Plummer: Matching Theory • Handbooks on Operations Research and Management Science Volume 7 (Editors: Ball, Magnati, Monma, Nemhauser) • J. Toran: Das Erfüllbarkeitsproblem SAT, Lehmann Media, 2012
Methods	Reworking of lectures and tutorials, self-studies with literature, solving exercises at home and in cooperation with other students at the tutorials
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 Minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Matthias Krause
Person in charge	Prof. Dr. Matthias Krause
Duration of module	1 semester
Further modules	CS 651 – Cryptography II
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsmathematik, M.Sc. Wirtschaftspädagogik, Lehramt Informatik, M.Sc. Mathematik
Semester	1./ 2. semester

CS 560	**Large-Scale Data Management**
Form of module	Lecture with exercises
Type of module	Computer Science Fundamental
Level	Master
ECTS	6
Workload	In presence: 42h (2+2 SWS)
	Exercises and self-study: 119 h
Prerequisites	Database systems, algorithms & data structures, Java programming
Aim of module	This course introduces the fundamental concepts and computational paradigms of large-scale data management and Big Data. This includes methods for storing, updating, querying, and analyzing large dataset as well as for data-intensive computing. The course covers concept, algorithms, and system issues; accompanying exercises provide hands-on experience. Topics include: • Parallel and distributed databases • Parallel database design • Distributed query processing • Big data processing (including MapReduce, Spark, Streaming) • Distributed transactions • NoSQL databases
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire knowledge about methods and systems for working with large datasets and data-intensive computing. (MK1, MK2)
	<u>Methodological competence:</u> • Be able to judge, select, and use traditional and modern data management systems for a given data intensive task • Be able to solve computational problems involving large datasets (MF1)
	<u>Personal competence:</u> • Study independently (MKO3)
Media	Slide set, black board, exercise sheets, datasets, software
Literature	• T. Öszu, P. Valduriez: *Principles of Distributed Database Systems* Springer, 4th ed., 2020 • H. Garcia-Molina, J. D. Ullman, J. Widom *Database Systems: The Complete Book* Prentice Hall, 2nd ed., 2008 • More in lecture notes

Methods	Lecture, weekly exercise, experimentation with different systems
Form of assessment	Written examination
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Rainer Gemulla
Person in charge	Prof. Dr. Rainer Gemulla
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1st / 2nd semester

CS 600	**Model-Driven Development**
Form of module	Lectures with accompanying tutorials
Type of module	Specialization course
Level	Master
ECTS	6
Workload	Hours per semester present at university: 56 h (4 SWS)
	Self-study: 112 h semester • 28 h: pre and post lecture studying and revision • 56 h: tutorial exercises • 28 h: directed independent study (reading papers, books etc.)
Prerequisites	Software Testing and Experimentation
Aim of module	The course focuses on the principles, practices and tools involved in advanced model-driven development. This includes established modelling standard languages (e. g. UML, ATL, OCL) and modelling infrastructures (e. g. MOF, EMF, …) as well as leading edge, state-of-the-art modelling technologies (e. g. LML, PLM . . .). Key topics addressed include: • Principles of Model-Driven Development • Meta-Modeling • Domain-Specific Languages • Model Constraint and Transformation languages • Multi-View/Multi-Paradigm Modeling • Multi-Level Modeling • Ontology Modeling • Enterprise Architecture Modeling
Learning outcomes and qualification goals	<u>Expertise:</u> Students will be familiar with the accepted best practices and technologies used in mainstream model-driven development as well as state-of-the-art modeling technologies emerging from research institutions. (MK1, MK2)
	<u>Methodological competence:</u> Students will know how to apply modeling technologies in real-world projects. (MF1, MF3)
	<u>Personal competence:</u> Students will have the capability to analyse, understand and model complex systems. (MKO1)
Media	Printed Lecture Notes, Presentations, Tool Demonstrations

Literature	• Jos B. Warmer and Anneke G. Kleppe, The Object Constraint Language: Getting Your Models Ready for MDA, Addison-Wesley Object Technology Series, 2003
Methods	Lectures, tutorials, independent study
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Colin Atkinson
Person in charge	Prof. Dr. Colin Atkinson
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	2nd, 3rd or 4th semester

CS 606	**Foundations of Artificial Intelligence: Search and Problem Solving**
Form der Veranstaltung	Vorlesung mit Übung
Typ der Veranstaltung	Vertiefung Informatik
Modulniveau	Master
ECTS	6
Arbeitsaufwand	Präsenzstudium: 56 h pro Semester (4 SWS)
	Eigenstudium: ca. 98 h pro Semester • davon Vor- und Nachbereitung der Veranstaltung und freies Selbststudium: 70 h pro Semester • davon Vorbereitung für die Prüfung, z.B. Prüfungs-/Seminarabschlussarbeits- und Präsentationsvorbereitung: 28 h pro Semester
Vorausgesetzte Kenntnisse	Formale Grundlagen der Informatik (insbes. Komplexität, Graphen und Logik), Algorithmen und Datenstrukturen, Programmierpraktikum I & II
Lehrinhalte	• Problemeigenschaften und Problemtypen • Problemlösen als Suche, Anwendung im Bereich Spiele • Constraintprobleme und deren Lösung • Logische Constraints • Entscheidungsbaumlernen
Lern- und Kompetenzziele	<u>Fachkompetenz:</u> Ziele und Grundlagen der Künstlichen Intelligenz. Suchverfahren als universelle Problemlösungsverfahren. Problemkomplexität und Heuristische Lösungen. Eigenschaften und Zusammenhang zwischen unterschiedlichen Suchverfahren. (BK7)
	<u>Methodenkompetenz:</u> Beschreibung konkreter Aufgaben als Such-, Constraint- oder Planungsproblem. Implementierung unterschiedlicher Suchverfahren und Heuristiken. (BF1, BKO1)
	<u>Personale Kompetenz:</u> -
Medienformen	Lehrbuch, Vorlesung, Präsentationen, Tafel
Begleitende Literatur	• Russel and Norvig: Artificial Intelligence – a modern approach. Prentice Hall. 3rd Edition 2010.
Lehr- und Lernmethoden	Vorlesung, praktische Übungen, Eigenständige Bearbeitung von Übungsaufgaben
Art der Prüfungsleistung	Schriftliche Prüfung
Prüfungsvorleistungen	• 1-2 Mini-Projekte erfolgreich bearbeitet und dokumentiert • Mindestens 60% aller Aufgabenpunkte aufsummiert

Prüfungsdauer	90 Minuten
Sprache	Deutsch/Englisch
Angebotsturnus	Herbstsemester
Lehrende/r	Dr. Christian Meilicke
Modulverantwortlicher	Prof. Dr. Heiner Stuckenschmidt
Dauer des Moduls	1 Semester
Weiterführende Module	SM 442 Bachelorseminar Prof. Stuckenschmidt
Verwendbarkeit	M. Sc. Wirtschaftsinformatik, B.Sc. Wirtschaftsinformatik, M. Sc. Wirtschaftspädagogik, Lehramt Informatik, Beifach Angewandte Informatik
Einordnung in Fachsemester	5./6. Fachsemester im B.Sc. Wirtschaftsinformatik, 1.2.3. Fachsemester im M. Sc. Wirtschaftsinformatik

CS 630	**Generative Software Engineering**
Form of module	Lectures, exercises, tutorials and projects
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 h (2 + 2 SWS)
	Self-study: 112 h per semester 28 h per semester for preparation and studying of lectures/tutorials 84 h per semester for the preparation of the exams
Prerequisites	• Software Testing and Experimentation • Knowledge of Java and/or Python
Aim of module	The course introduces the fundamental principles, practices and applications of generative software engineering (GSE) as well as the supporting models, tools and services - • Software Recommendation and Reuse • Code Search Engines • Principles of GSE • Existing GSE models, tools and services • Defining GSE “problems” • Applications of GSE • Evaluation and comparison of GSE models, tools and services
Learning outcomes and qualification goals	<u>Expertise:</u> Students will be familiar with the principles, practices and applications of GSE as well as supporting models, tools and services. (MK1, MK2)
	<u>Methodological competence:</u> Students will have the ability to judge, select, and apply GSE techniques and tools in practical software engineers, as well as the ability to understand academic GSE publications and to perform research in GSE. (MF1, MF2, MF3)
	<u>Personal competence:</u> Students will have improved skills in analytical thinking and applying theoretical knowledge to solve practical problems, especially in the use of AI to enhance software engineering. (MKO1, MKO3)

Media	Students acquire knowledge of the principles, practices and applications of GSE, including supporting models, tools and services and methods, through lectures and tutorials. The students apply their knowledge individually and in team projects and report their findings in written reports and oral presentations.
Literature	
Methods	Lectures, weekly exercises, experimentation with different systems
Form of assessment	Project reports (70%), oral presentations (30%)
Admission requirements for assessment	
Duration of assessment	
Language	English
Offering	Spring semester
Lecturers	Dr. Marcus Kessel
Person in charge	Dr. Marcus Kessel
Duration of module	1 Semester
Further modules	Model-Driven Development, Software Testing and Experimentation
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	2nd, 3rd or 4th semester

CS 651	**Cryptography II**
Form of module	Inverted classroom
Type of module	Specialization course
Level	Master
ECTS	6
Workload	Hours per semester present: 56h (4 SWS) Self-study: 112h
Prerequisites	Even though the lecture deepens and continues topics discussed in *"CS 404 Cryptography I"*, it is not a prerequisite to have attended this lecture. The lecture "*Cryptography II"* can be studied without any prior knowledge on cryptography – all necessary basics are shortly recapitulated.
Aim of module	The goal of this lecture is to present and discuss important scientific concepts from modern cryptography. This includes: • Security Definitions: How can the security of cryptographic schemes formally defined? • Proofs of Security: How can the security of cryptographic schemes be proven (based on precise assumptions)? • Cryptanalysis: What are the established techniques to analyze cryptographic mechanisms? • Elliptic Curves • Zero-Knowledge Proofs
Learning outcomes and qualification goals	<u>Expertise:</u> With the help of current techniques and theories of modern cryptography, the students can assess the security of cryptographic processes and assess security statements accordingly. Furthermore, they can identify security goals and use appropriate techniques that could not be dealt with in "*CS 404 Cryptography I*". (MK2)
	<u>Methodological competence:</u> The students can select and use suitable methods for the security analysis of cryptographic processes. This includes, for example, the choice of the appropriate security model, proof of security based on clearly specified assumptions and the analysis of given procedures. In particular, the students can understand and assess the security arguments for existing procedures and to transfer them to new ones. Furthermore, they can use techniques and protocols to achieve security goals that were not yet possible with the methods discussed in *"CS 404 Cryptography I"*. (MK1)
	<u>Personal competence:</u>

	The analytic, concentrated, and precise thinking of the students is trained. By the independent treatment of applications, e.g. in the course of the exercises, their abstraction capacity is further developed and the transfer of the learned material to related questions is trained. (MF1, MKO3)
Media	Video recordings, annotated lecture slides
Literature	• Jonathan Katz, Yehuda Lindell: Introduction to Modern Cryptography: Principles and Protocols, Chapman and Hall/CRC, 2007.
Methods	Reworking the lecture and studying the relevant literature in self-study. During the lecture: discussing questions and ideas and working together on concrete examples. Solving exercises in self-study and in practice in cooperation with fellow students.
Form of assessment	Oral exam
Admission requirements for assessment	none
Duration of assessment	30 minutes
Language	English
Offering	HWS
Lecturer	Prof. Dr. Frederik Armknecht
Person in charge	Prof. Dr. Frederik Armknecht
Duration of module	One term
Further modules	none
Range of application	M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsinformatik, Lehramt Informatik, M.Sc. Mathematik
Semester	1st/2nd/3rd semester

CS 655	**Cryptography**
Form of Module	Lecture with Exercise
Type of Module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 (4 SWS)
	Self-study: 98h (70h lectures/exercises, 28h exam preparation)
Prerequisites	Basis skills in linear algebra, probability theory, algorithms, and data structures
Aim of Module	• Basic concepts of cryptography • Mathematical Background • Basics of Information Theory • Block Ciphers (DES, AES, etc.) • Stream Ciphers • Secure Key Exchange Protocols (Diffie-Hellman protocol, etc.) • Public Key encryption (RSA) • Cryptographic Hash Functions • Signature Systems and Message Authentication Codes
Learning Outcomes and qualification goals	<u>Expertise:</u> After the course the students are able to identify security risks in various modern scenarios of data traffic like online banking, wireless communication, online trade ... (MK1)
	<u>Methodological competence:</u> The students are able to formulate and formalize security goals for various use cases and to choose and to apply appropriate methods to reach these goals. Examples here are to provide data security data encryption, to establish trusted electronical data encryption, to establish trusted electronical communication channels, or to apply methods for secure authentication (MF1)
	<u>Personal competence:</u> The course trains abstract thinking and the ability to formally model application scenarios. By solving exercises independently, the transfer of the learned material to related questions is promoted.
Media	Exercise sheets and lecture slides available online, blackboard
Literature	• Christof Paar, Bart Preneel, Jan Pelzl: Understanding Cryptography: A Textbook for Students and Practitioners, Springer 2009 • Douglas R. Stinson: Cryptography - Theory and Practice, Taylor & Francis, 2005

	• Alan G. Konheim: Cryptography: A Primer, John Wiley & Sons, 1981
Methods	Lecture, exercises every two weeks, book studies
Form of assessment	Oral examination
Admission requirements for assessment	-
Duration of assessment	15 – 30 minutes
Language	English
Offering	FSS not offered in FSS 26
Person in Charge	Prof. Dr. Matthias Krause
Duration of Module	1 Semester
Further Modules	Cryptography II
Range of Application	M.Sc Business Informatics, M.Sc Data Science, Lehramt Informatik, B.Sc. Wirtschaftsmathematik
Semester	1st/2nd/3rd Semester

CS 664	**Blockchain Security**
Form of module	Inverted classroom with exercises
Type of module	Specialization course
ECTS	6
Workload	Hours per semester present: 56h (4 SWS), Self-study: 112h
Prerequisites	There are no formal prerequisites but knowledge in cryptography and/or IT-security is recommended, e.g., by attending the lectures “Kryptographie I” or “Selected Topics in IT-Security”
Aim of module	Blockchains promise secure and reliable data storage and consensus in a trustless environment. In the light of their growing popularity, Blockchain security becomes increasingly important. The course will equip students with a solid understanding of blockchains, their design principles, underlying technologies, and cryptographic primitives. Bitcoin, Monero and Ethereum will be discussed in greater detail and a substantial part of the course will be devoted to security issues and possible attacks.
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire profound knowledge of Blockchain technology as well as the skills to critically examine the security of Blockchain-based systems. (MK1, MK2)
	<u>Methodological competence:</u> Successful participants will be able to understand and evaluate the different ways in which different Blockchain systems try to achieve security. They will also be able to identify where, why, and how these security measures are broken for both, current and new systems. (MKO3)
	Personal competence: The analytic, concentrated, and precise thinking of the students is trained. As multiple different but related Blockchains are discussed, their abstraction capacity is further developed and the transfer of the learned concepts to related questions is trained. (MF1)
Media	Video recordings, annotated lecture slides
Literature	Will be announced in the lecture
Methods	Reworking the lecture and studying the relevant literature in self-study. During the lecture: discussing questions and ideas and working together on concrete examples. Solving exercises in self-study and in practice in cooperation with fellow students.
Form of assessment	Written exam

Admission requirements for assessment	-
Duration of assessment	90 Minutes
Language	English
Offering	HWS
Lecturer	Prof. Dr. Frederik Armknecht
Person in charge	Prof. Dr. Frederik Armknecht
Duration of Module	1 Semester
Further Modules	-
Range of application	M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsinformatik Lehramt Informatik M.Sc. Mathematik M.Sc. Wirtschaftsmathematik
Semester	1st/2nd/3rd semester

IE 650	**Knowledge Graphs**
Form of module	Lecture
Type of module	Specialization course
Level	Master
ECTS	6
Workload	Hours per semester present at university: 56 h (4 SWS)
	Self-study: 124 h per semester • 82 h: pre and post lecture studying and revision • 42 h: examination preparation
Prerequisites	Java or Python programming skills
Aim of module	• The Role of knowledge graphs in the AI landscape • Semantic Web and its representation languages • Labeled property graphs • Query languages for knowledge graphs • Knowledge modeling and ontologies • Logical reasoning with knowledge graphs • Machine learning with knowledge graphs and knowledge graph embeddings
Learning outcomes and qualification goals	<u>Expertise:</u> The participants of this course learn about principles and applications of knowledge graphs. They become familiar with their technical foundations such as representation and query languages, or logical inference. After taking this course, the students will be aware of the problems and benefits of knowledge graph technologies in the context of tasks such as knowledge management, information search and data integration, and they will be capable of judging the applicability of these technologies for addressing practical challenges. (MK1, MK2)
	<u>Methodological competence:</u> The participants learn how to design and implement AI systems based on knowledge graphs. They are able to use standardized modeling languages for building knowledge representations, and to query these models by means of languages such as SPARQL. (MF3)
	<u>Personal competence:</u> By jointly building a knowledge graph-based application, the students learn how to effectively work in teams. They improve upon their presentation skills by showing the outcomes of their projects to the other participants of the course. (MKO1, MKO3)
Media	Lecture slides and exercise sheets will be available online

Literature	• Pascal Hitzler, Markus Krötzsch and Sebastian Rudolph, Foundations of Semantic Web Technologies, Chapman & Hall/CRC, 2009 • Allemang and Hendler (2008): Semantic Web for the Working Ontologist. Verlag Morgan Kaufmann. • Antoniou and van Harmelen (2004): A Semantic Web Primer. MIT Press. • Fensel et al. (2020): Knowledge Graphs: Methodology, Tools and Selected Use Cases. Springer. • Kerjwal et al. (2021): Knowledge Graphs: Fundamentals, Techniques, and Applications. MIT Press.
Methods	The course participants will take part in theoretical and practical exercises, the solutions of which are discussed in the tutorials. At the end of the course, they get the opportunity to apply their knowledge in a team project. Each student team will design and implement a semantic web application, and subsequently present the results to the other students. Besides the exercises, regular presentations including references to relevant course materials and recommended readings will be given by the lecturer. The lecturer as well as the tutors offer individual help and consulting to the participants of the course.
Form of assessment	Written examination
Admission requirements for assessment	Project report and oral presentation
Duration of assessment	60 minutes
Language	English
Offering	Fall semester
Lecturer	Dr. Sven Hertling
Person in charge	Prof. Dr. Heiko Paulheim; Dr. Sven Hertling
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, M.Sc Mannheim Master in Social Data Science, Lehramt Informatik
Semester	1st/2nd/3rd semester

IE 663	**Information Retrieval and Web Search**
Form of module	Lecture
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester present: 28h (2SWS)
	Self-study: 60h per semester • Pre- and post- lecture studying and preparation (30h) • Examination preparation (30h)
Prerequisites	Fundamental notions of linear algebra, probability theory, as well as algorithms and data structures
Aim of module	Given the vastness and richness of the Web, users need high-performing, scalable and efficient methods to access its wealth of information and satisfy their information needs. As such, being able to search and effectively retrieve relevant pieces of information from large text collections is a crucial task for the majority of Web applications. In this course, we will explore a variety of techniques for text-based information retrieval and Web search. Covered topics will include: • Efficient text indexing; • Boolean and vector space retrieval models; • Probabilistic and semantic ad-hoc retrieval; • Evaluation of retrieval systems; • Text classification and clustering; • Web search, crawling and link-based algorithms. This course provides theoretical information retrieval foundations. As such is highly to be attended together with the course Information Retrieval Project (IE 691).
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire knowledge of fundamental techniques of Information Retrieval and Web Search, including standard retrieval models, evaluation of information retrieval systems, text classification and clustering, as well as web search topics such as crawling and link-based algorithms. (MK1, MK2)
	<u>Methodological competence:</u> Successful participants will be able to understand state-of-the-art methods for Information Retrieval and Web search, as well as being able to select, apply and evaluate the most appropriate techniques for a variety of different search scenarios. (MF1, MF3)
	<u>Personal competence</u>: -

Media	Lecture slides, exercise sheets
Literature	• Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. • R. Baeza-Yates, B. Ribeiro-Neto, Modern Information Retrieval, Addison-Wesley, 2011 (2nd Edition).
Methods	The course consists of (1) lectures that introduce the students to traditional and contemporary information retrieval techniques and models, and (2) exercises in which the students are demonstrated in terms of comprehensible examples how theoretically introduced models work.
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Simone Paolo Ponzetto; Dr. Daniel Ruffinelli
Person in charge	Prof. Dr. Simone Paolo Ponzetto
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, MMDS, MMSDS, Lehramt Informatik
Semester	$1^{st}/2^{nd}/3^{rd}$ semester

IE 670	**Web Data Integration**
Form of module	Lecture
Type of module	Specialization course
Level	Master
ECTS	3
Workloadk	Hours per semester: 28 h (2 SWS)
	Self-study: 56 h per semester • 31 h: pre and post lecture studying and revision • 25 h: examination preparation
Prerequisites	-
Aim of module	Data integration is one of the key challenges in most IT projects and it is estimated that data scientists spend about 80% of their time on data integration and data preparation. Within the enterprise context, data integration problems arise whenever data from separate sources needs to be combined as the basis for new applications or data analysis projects. Within the context of the Web, data integration techniques form the foundation for taking advantage of the ever-growing number of publicly-accessible data sources. The course will cover the following topics: 1. Heterogeneity and Distributedness 2. The Data Integration Process 3. Structured Data on the Web 4. Data Exchange Formats 5. Schema Mapping and Data Translation 6. Identity Resolution 7. Data Quality Assessment 8. Data Fusion It is highly recommended to attend the course IE683 Web Data Integration Project in the same semester as this course as the schedules of both courses are aligned to each other.
Learning outcomes and qualification goals	<u>Expertise:</u> Students will be able to identify opportunities for employing Web data in business applications and will learn to select and apply appropriate techniques for integrating and cleansing Web data. (MK1, MF1)
	<u>Methodological competence:</u> Participants will acquire knowledge of the data integration process as well as the techniques that are used in each phase of the process. (MK2, MF3, MF4, MKO3)

	Personal competence: -
Media	slide set
Literature	• AnHai Doan, Alon Halevy, Zachary Ives: Principles of Data Integration. Morgan Kaufmann, 2012. • Luna Dong, Divesh Srivastava: Big Data Integration. Morgan & Claypool, 2015. • Ulf Leser, Felix Naumann: Informationsintegration. Dpunkt Verlag, 2007.
Methods	The course consists of a lecture that introduces students to state of the art data integration techniques.
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	60 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Christian Bizer
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, M.Sc. Mannheim Master in Social Data Science, Lehramt Informatik
Semester	1st/2nd/3rd semester

IE 683	**Web Data Integration Project**
Form of module	Project
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester: 28 h (2 SWS)
	Self-study: 56 h per semester • 36 h: project work • 20 h: report writing and presentation preparation
Prerequisites	Programming skills in Python
Aim of module	The web data integration project allows students to apply the methods and techniques that they have learned in the lecture Web Data Integration in the context of a practical integration project. The projects cover all steps of the data integration process including data gathering, schema mapping, data translation, identity resolution, data quality assessment, and data fusion. It is highly recommended to attend the web data integration lecture (IE670) in the same semester as the web data integration project as the schedules of both courses are aligned to each other.
Learning outcomes and qualification goals	<u>Expertise:</u> • Students will be able to identify opportunities for employing Web data in business applications and will learn to apply appropriate techniques for integrating and cleansing Web data. (MK1, MF1)
	<u>Methodological competence:</u> • Participants will acquire knowledge of the data integration process as well as the techniques that are used in each phase of the process. • project organization skills (MK2, MF3, MF4, MKO3)
	<u>Personal competence:</u> • presentation skills • team work skills (MKO2, MF2)
Media	exercise sheets; Java project template
Literature	• AnHai Doan, Alon Halevy, Zachary Ives: Principles of Data Integration. Morgan Kaufmann, 2012. • Luna Dong, Divesh Srivastava: Big Data Integration. Morgan & Claypool, 2015. • Ulf Leser, Felix Naumann: Informationsintegration. Dpunkt Verlag, 2007.

Methods	Students work on their integration projects in teams and will report about the results of their projects in the form of a written report as well as an oral presentation.
Form of assessment	Project report (70%, 10-20 pages in length), oral project presentation (30%, 15-20 minutes)
Admission requirements for assessment	-
Duration of assessment	-
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Christian Bizer
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Mannheim Master in Data Science, Mannheim Master in Social Data Science, Lehramt Informatik
Semester	1. /2. /3. Semester

IE 691	**Information Retrieval Project**
Form of module	Project
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester present: 28h (2SWS)
	Self-study: 60h per semester • Project work (45h) • Report and presentation preparation (15h)
Prerequisites	Programming skills (preferably in one of the higher-level programming languages: Java/Python/C#/C++).
Aim of module	Students are expected to successfully complete a team project in teams of 2-4 members. The projects will focus on a variety of IR problems and implementation of IR models theoretically covered in the course Information Retrieval and Web Search (IE 663). It is thus highly recommended to attend this course together with the course IE 663. Project deliverables include both software (i.e., code and documentation) and a short report explaining the work performed and its evaluation. The students are expected to clearly and coherently present the project results.
Learning outcomes and qualification goals	<u>Expertise:</u> Students will be able to solve real-world retrieval and search problems: they will be able to analyze different potential solutions to a given problem, identify their advantages and shortcomings, and decide for the best solution. (MK1, MF1)
	<u>Methodological competence:</u> Students will obtain skills needed to implement one or more information retrieval models and test their usefulness on real-world problems. Successful participants will be able to fully understand state-of-the-art methods for Information Retrieval and Web search, through hands-on experience of implementing those models. Students will also develop and/or improve their project organization skills (activity planning, work breakdown, time planning, etc.) (MK2, MF3, MF4, MKO3)
	Personal competence:
	• Presentation skills • Team work skills (MKO2, MF2)
Media	Project task specifications

Literature	• Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. • B. Croft, D. Metzler, T. Strohman, Search Engines: Information Retrieval in Practice, Addison-Wesley, 2009 • R. Baeza-Yates, B. Ribeiro-Neto, Modern Information Retrieval, Addison-Wesley, 2011 (2nd Edition).
Methods	Students work on implementing an information retrieval system in order to solve a real-world search problem. Students work in teams, implement the programmatic solutions to the tasks, organize their knowledge and results into a project report, and present the obtained results.
Form of assessment	Project report (70%, 10-20 pages in length), oral project presentation (30%, 20-30 minutes).
Admission requirements for assessment	-
Duration of assessment	4-6 weeks (execution of the project work and writing of the report), 20-30 minutes (presentation).
Language	English
Offering	HWS
Lecturer	Prof. Dr. Simone Ponzetto
Person in charge	Prof. Dr. Simone Ponzetto
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Lehramt Informatik, MMDS, MMSDS
Semester	1st/2nd/3rd semester

DS 200	**Sampling and Data**
Form of module	Lecture and Tutorial
Type of module	Data Science Methods: Fundamentals
Level	Master
ECTS	9 (270 hours)
Workload	Hours per semester present: 56 h (4 SWS)
	Self-study: 214 h per semester • 91 h: pre and post lecture studying and revision • 42 h: studying for and taking weekly online tests • 41 h: preparation and presentation of weekly exercises • 40 h: examination preparation
Prerequisites	-
Aim of module	The course introduces the relevant methods for research design and data analysis in the social science. The course will center on causal inference, identification, and estimation. Reading and critiquing papers will be emphasized along with the data and statistical analyses.
Learning outcomes and qualification goals	<u>Expertise:</u> Students can independently formulate research questions and empirically verifiable hypotheses. (MK1)
	<u>Methodological competence:</u> Students know different data collection methods and their advantages and disadvantages; they are able to assess the appropriateness of the methods used to answer various questions; they understand and critically evaluate the design of empirical studies. (MK1)
	<u>Personal competence:</u> The course supports students to develop competences with regard to choosing the appropriate research design and sampling frame. (MF2, MKO1, MKO2)
Media	Lecture slides available online
Literature	• Angrist, Joshua D., and Jörn-Steffen Pischke. 2009. Mostly Harmless Econometrics: An Empiricist's Companion. Princeton: Princeton University Press. • Imbens, Guido W., and Donald B. Rubin. 2015. Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction. Cambridge: Cambridge University Press. • Cunningham, Scott. 2021. Causal Inference: The Mixtape. New Haven and London: Yale University Press.
Methods	Lecture elements, weekly tests, literature studies

Form of assessment	Written examination
Admission requirements for assessment	Oral participation, homework, presentations, compulsory attendance
Duration of assessment	90 Minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Marc Ratkovic
Person in charge	Prof. Dr. Marc Ratkovic
Duration of module	1 semester
Further modules	
Range of application	M.Sc. Mannheim Master in Data Science, M.Sc. Mannheim Master in Social Data Science

MAC 570	**Reinforcement Learning - Coding**
Form of module	Lectures with exercises
Type of module	Mathematics elective
Level	Master
ECTS	5
Workload	28 hours lectures 122 hours self-studies
Prerequisites	Reinforcement Learning
Aim of module	• Implementation of standard algorithms in reinforcement learning • Bandit algorithms (UCB) • TD algorithms (Q-learning, TD) • Policy gradient algorithms (SAC, PPO)
Learning outcomes and qualification goals	MK1, M02, M03
	MF1, MF3
	(cf, “Erläuterungen zu den Abkürzungen”)
Media	Blackboard, Slides
Literature	Original articles
Methods	Lectures, programmig tasks
Form of assessment	Written exam
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Irregular
Lecturer	Prof. Dr. Leif Döring, Prof. Dr. Simon Weißmann
Person in charge	Prof. Dr. Leif Döring, Prof. Dr. Simon Weißmann
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsmathematik, M.Sc. Mathematik, M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsinformatik
Semester	1./2./3. semester

D. Data Analytics Methods

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
AC 652	Additional Course – Data Analytics Methods	HWS/FSS	E	Max. 18	47
DA 110	Computational Analysis of Communication	HWS/FSS	E	6	48
DS 201	Machine Learning and Causal Inference	FSS	E	9	50
DS 202	Seminar and Lab on Machine Learning and Causal Inference	HWS	E	9	52
IE 500	Data Mining	HWS/FSS	E	6	54
IE 560	Decision Support	HWS	E	6	56
IE 671	Web Mining not offered in FSS 26	FSS	E	3	58
IE 675b	Machine Learning	HWS	E	9	60
IE 678	Deep Learning	FSS	E	6	62
IE 684	Web Mining Project not offered in FSS 26	FSS	E	3	64
IE 686	Large Language Models and Agents (Project)	HWS	E	3	66
IE 694	Artificial Intelligence Applications in Industry	FSS	E	6	68
IE 695	Reinforcement Learning	HWS	E	6	70
IE 696	Advanced Methods in Text Analytics	FSS	E	6	72
IE 698	Foundations and Applications of Digital Health Technologies	FSS	E	3	74
IE 699	Co-creating digital health applications with design methodology	FSS	E	6	76
IS 515	Process Management and Analytics	HWS	E	6	MMM*
IS 616	Large Scale Data Analysis and Visualization not offered in FSS 26	HWS	E	6	MMM*
IS 622	Network Science***	FSS	E	6	MMM*
IS 661	Text Analytics	HWS	E	6	MMM*
MAA 519	Stochastic Calculus	HWS	E	5	MBE*
MAB 504	Mathematics and Information	irregular	G	8	MBE*

MAB 508	Algebraische Statistik	irregular	G/E	8	MBE*
MAB 519	Reinforcement Learning****	FSS	E	10	MBE*
MAB 520	Reinforcement Learning II	HWS	E	5	MBE*
MAC 404	Optimierung	HWS	G	8	WM*
MAC 502	Computational Finance	FSS	G/E	6	MBE*
MAC 507	Nichtlineare Optimierung	FSS	G/E	6	MBE*
MAC 527	Markov Processes	FSS	E	4	MBE*
MKT 511	Marketing Analytics	FSS	E	6	MMM*
MKT 545	Customers, Markets and Firm Strategy	FSS	E	6	MMM*
	Lecture Cross Sectional Data Analysis	HWS	E	6	Soc*
	Tutorial Cross Sectional Data Analysis	HWS	E	3	Soc*
	Lecture Advanced Quantitative Methods	FSS	E	6	PS*
	Tutorial Advanced Quantitative Methods	FSS	E	2	PS*
	Lecture Longitudinal Data Analysis	FSS	E	6	Soc*
	Tutorial Longitudinal Data Analysis	FSS	E	3	Soc*
	Lecture Research Design	HWS	E	6	Soc*
	Tutorial Research Design	HWS	E	3	Soc*
	Empirische Methoden der Politikwissenschaft	HWS	E	6	PW*
CS 646	Higher Level Computer Vision	HWS	E	6	78
CS 647	Image Processing	FSS	E	6	80
CS 668	Generative Computer Vision Models	FSS	E	6	82
DS 201	Machine Learning and Causal Inference	FSS	E	9	50

* For a detailed description, please see the module catalogues of the respective following degree programs:

- WM: B.Sc. Wirtschaftsmathematik https://www.wim.uni-mannheim.de/studium/studienorganisation/b-sc-wirtschaftsmathematik/ (only available in German)
- MBE: M.Sc. Mathematics in Business and Economics https://www.wim.uni-mannheim.de/studium/studienorganisation/m-sc-wirtschaftsmathematik/ (only available in German)

- PS: M.A. Political Science
  https://www.sowi.uni-mannheim.de/studium/studierende/politikwissenschaft/ma-political-science/
  (only available in German)
- PW: B.A. Politikwissenschaft
  https://www.sowi.uni-mannheim.de/en/academics/students/political-science/ba-in-political-science/
  (only available in German)
- Soc: M.A. Sociology
  https://www.sowi.uni-mannheim.de/studium/studierende/soziologie/ma-sociology/
- MMM: Mannheim Master in Management
  https://www.bwl.uni-mannheim.de/en/module-catalog-mmm/

***Prerequisite: Not completed exam in IE 676

****Prerequisite: Not completed exam in IE 695

2. Detailed descriptions

AC 652	**Additional Course – Data Analytics Methods**
Form of module	Depends on course
Level	Master
ECTS	Max. 18
Workload	Depends on course
Prerequisites	Depends on course
Aim of module	The course falls into the data analytics methods area of the MMDS and covers topics related to data analytics methods but is not directly equivalent to any course in the MMDS module catalogue. The course level equals a regular course in MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.
Learning outcomes and qualification goals	Depends on course
Media / Literature / Methods / Form and duration of assessment	Depends on course
Language	English preferred, but any other language possible if Mannheim faculty member is able to identify content and level
Offering	Spring semester / Fall semester
Lecturer	Lecturer at the host university
Person in charge	Lecturer at the host university
Duration of module	1 Semester
Further modules	-
Range of application	MMDS
Semester	2nd/3rd/4th semester

DA 110	**Computational Analysis of Communication**
Form of module	Exercise
Type of module	Data Analytics Methods
Level	Master
ECTS	6
Workload	Hours per semester present: 28 (2 SWS)
	Self-study: 145h (70h lectures/exercises, 75h research report)
Prerequisites	Basic skills in descriptive and inferential statistics, basic knowledge of data structures and data wrangling procedures, machine learning, web-scraping/web-mining
Aim of module	As “big data” and “algorithms” affect our daily communication, new research questions arise at the intersection between societies and technologies. Many of these questions are of great social relevance and are therefore prominently discussed both by researchers and in the media. One outstanding, recent example from the field of media psychology is a rising interest in the association of (social) media use and mental health. Another example, from the realm of political communication, is the ongoing debate about the role of new communication technologies during political campaigns (e.g., to spread disinformation). Both questions revolve around the process of communication. Sound research in this area thus requires both a solid foundation from communication theory as well as expertise in handling new and “big” data. To close this gap, the growing discipline of Computational Communication Science (CCS) takes on a combinatory perspective between social and computer science. The present course will provide an overview about the current state of CCS and intends to motivate students to approach pressing social questions from a different perspective.
Learning outcomes and qualification goals	<u>Expertise:</u> After the course the students are aware of the typical research topics and questions in automated media content analyses and the different methodological approaches for tackling them; they know the different methods’ potentials, limitations, and typical fields of application; they are able to develop their own specific research questions and can make an informed decision about which method to apply for answering it (MK3).
	<u>Methodological competence:</u>

	Students are able to independently develop a research question and design in the area of automated media content analysis and can conduct a respective analysis using one of the different methodological ap-proaches introduced in the exercise; they are able to document the results of their analyses in a research report and reflect upon their find-ings' limitations with regards to reliability and validity. (MF1, MF2, MF3, MF4, MF5)
	<u>Personal competence:</u> The course supports students to develop problem-solving competences with regards to research-design oriented questions. By solving exercises independently, the transfer of the learned material to related questions is promoted and self-confidence with regards to research-oriented tasks is gathered (MKO3).
Media	Exercise sheets and lecture slides are available online
Literature	van Atteveldt, W., Trilling, D., & Arcila, C. (2021). Computational Analysis of Communication: A practical introduction to the analysis of texts, networks, and images with code examples in Python and R. http://cssbook.net/
Methods	Lecture elements, student presentations, weekly exercises, literature studies
Form of assessment	Written research report (10 – 12 pages)
Admission requirements for assessment	-
Duration of assessment	4-8 weeks, depending on the topic
Language	English
Offering	HWS/FSS
Lecturer	Dr. Rainer Freudenthaler
Person in charge	Dr. Rainer Freudenthaler
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Data Science
Semester	1st/ 2nd/3rdsemester

DS 201	**Machine Learning and Causal Inference**
Form of module	Lecture and Tutorial
Type of module	Data Science Methods: Fundamentals
Level	Master
ECTS	9 (270 hours)
Workload	Hours per semester present: 56 h (2 SWS)
	Self-study: 214 h per semester • 91 h: pre and post lecture studying and revision • 42 h: studying for and taking weekly online tests • 41 h: preparation and presentation of weekly exercises • 40 h: examination preparation
Prerequisites	A sound understanding of basic statistical methods incl. regression analysis, estimation methods (OLS, MLE), and statistical inference is required. Knowledge in linear algebra and calculus is also required. This is the third in a three-course sequence covering statistical models and causal inference for MMSDS. The topics in all three courses (DS 100, DS 200) will be integrated. It is expected that students will take both semesters.
Aim of module	The course aims to introduce students to likelihood-based and Bayesian methods, machine learning methods, then deep learning methods. Extensions and connections to causal methods will be made at each stage. Advanced and popular techniques of machine learning are introduced.
Learning outcomes and qualification goals	<u>Expertise:</u> Students are aware of how machine learning can help answer causal questions; they can analyze (large) data sets using popular techniques of machine learning. (MK1)
	<u>Methodological competence:</u> Students are able to translate their research question(s) into a causal framework; they can apply different techniques of machine learning. (MK1, MK3)
	<u>Personal competence:</u> The course supports students to develop competences with regard to choosing the appropriate statistical method(s) to answer respective research questions. (MF1, MF2, MF4, MKO1, MKO2)
Media	Lecture slides available online

Literature	• McElreath, Richard. 2020. Statistical Rethinking: A Bayesian Course with Examples in R and STAN. Routledge. • Murphy, Kevin P. 2012. Machine Learning: A Probabilistic Perspective. Cambridge: MIT Press. • Hastie, Trevor, Robert Tibshirani, and Jerome Friedman. 2008. The Elements of Statistical Learning. 2nd ed. New York: Springer. • Jurafsky, Daniel, and James H. Martin. 2009. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition. 2nd ed. Upper Saddle River, NJ: Prentice Hall. • Imbens, Guido W., and Donald B. Rubin. 2015. Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction. Cambridge: Cambridge University Press.
Methods	Lecture elements, weekly tests, literature studies
Form of assessment	Written examination
Admission requirements for assessment	Oral participation, homework, presentations, compulsory attendance
Duration of assessment	90 Minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Marc Ratkovic
Person in charge	Prof. Dr. Marc Ratkovic
Duration of module	1 semester
Further modules	
Range of application	MMSDS, MMDS
Semester	2nd semester

DS 202	**Seminar and Lab on Machine Learning and Causal Inference**
Form of module	Seminar
Type of module	Data Science Methods: Fundamentals
Level	Master
ECTS	9 (270 hours)
Workload	Hours per semester present: 56 h (4 SWS)
	Self-study: h per semester • 70 h: pre and post seminar studying and revision • 70 h: analyzing data, programming Python scripts • 74 h: preparation and presentation of research project
Prerequisites	Students should be familiar with Python or R or at least with any other object-programming language.
Aim of module	The module introduces, discusses, and offers hands-on experience in state-of-the-art topics in data science. It consists of a "theoretical" part (seminar) which offers room for discussion on hot topics of data science and an "empirical" part where students formalize research questions and analyze data (of their own) using advanced techniques of machine learning.
Learning outcomes and qualification goals	<u>Expertise:</u> Students are able to find appropriate techniques of machine learning to answer complex research questions; they can analyze (large) data sets using state-of-the-art techniques of machine learning. (MK1)
	<u>Methodological competence:</u> Students are able to program in Python; they can apply advanced techniques of machine learning to individual research questions; they have in-depth knowledge in application of data science. (MK1, MK2, MK3)
	<u>Personal competence:</u> Students are able to independently implement their research question in a research project; they can deal with and solve theoretical and empirical problems. (MF1, MF2, MF3, MF4, MKO1, MKO2)
Media	Slides available online
Literature	• Downey, Allen B. 2016. Think Python. How to Think Like a Computer Scientist. 2nd ed. Needham: Green Tea Press. (available online: http://greenteapress.com/thinkpython2/thinkpython2.pdf)

	• McElreath, Richard. 2020. Statistical Rethinking: A Bayesian Course with Examples in R and STAN. Routledge. • Martin and Jurafsky. 2024. Speech and Language Processing. Available at https://web.stanford.edu/~jurafsky/slp3/. • Guttag, John V. 2021. Introduction to Computation and Programming Using Python. 3rd. ed. Cambridge: MIT Press. • The Python Tutorial (online: https://docs.python.org/3/tutorial/)
Methods	Lecture elements, classroom discussion, weekly lab-sessions, literature studies, external speakers
Form of assessment	Written examination
Admission requirements for assessment	Oral participation, homework, presentations, compulsory attendance
Duration of assessment	90 Minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Marc Ratkovic
Person in charge	Prof. Dr. Marc Ratkovic
Duration of module	1 semester
Further modules	
Range of application	MMSDS
Semester	3rd semester

IE 500	**Data Mining**
Form of module	Lecture with exercises and project
Type of module	Business Informatics Fundamental
Level	Master
ECTS	6
Workload	Hours per semester: 56 h (4 SWS)
	Self-study per semester: 98 h • 70 h: pre and post lecture studying and revision • 28 h: examination preparation
Prerequisites	Foundations of Statistics, Practical Informatics I
Aim of module	The course provides an introduction to advanced data analysis techniques as a basis for analyzing business data and providing input for decision support systems. The course will cover the following topics: • Goals and Principles of Data Mining • Data Representation and Preprocessing • Classification • Regression • Cluster Analysis • Association Analysis • Practical Data Mining using Python
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire basic knowledge of the techniques, opportunities, and applications of data mining. (MK1, MF1)
	<u>Methodological competence:</u> Successful participants will be able to identify opportunities for applying data mining in an enterprise environment, select and apply appropriate techniques, and interpret the results. project organization skills (MK2, MF3, MF4, MKO1)
	<u>Personal competence:</u> team work skills presentation skills (MKO2, MF2)
Media	Slide set, exercise sheets, Jupyter notebooks, data sets for the exercises, lecture videos
Literature	• Pang-Ning Tan, Michael Steinback, Vipin Kumar: Introduction to Data Mining, 2nd Edition, Pearson. • Aurélien Géron: Hands-on Machine Learning with Scikit-Learn, Keras & TensorFlow, 3rd Edition, O'Reilly.

Methods	The course consists of a lecture together with accompanying practical exercises as well as student team projects. In the exercises the participants will gather initial expertise in applying state of the art data mining tools on realistic data sets. The group projects take place in the last third of the term. Within the projects, students implement advanced data mining projects of personal choice and report about the results of their projects in the form of a written report as well as an oral presentation.
Form of assessment	Written examination (75%), project report (20%), oral project presentation (5%)
Admission requirements for assessment	-
Duration of assessment	60 minutes (written examination), 5-11 pages (project report), 5-15 minutes (oral project presentation)
Language	English
Offering	Fall semester / Spring semester
Lecturer	Prof. Dr. Heiko Paulheim; Prof. Dr. Christian Bizer; Dr. Sven Hertling
Person in charge	Prof. Dr. Heiko Paulheim; Prof. Dr. Christian Bizer; Dr. Sven Hertling
Duration of module	1 Semester
Further modules	IE 675b – Machine Learning, IE 678 – Deep Learning, IS 661 – Text Analytics, CS 646 – Higher Level Computer Vision, IE 671 – Web Mining
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1st/2nd semester

IE 560	**Foundations of Artificial Intelligence – Reasoning and Decision Making**
Form of module	Inverted classroom
Type of module	Business Informatics Fundamental
Level	Master
ECTS	6
Workload	Hours per semester: 50 h (2+2 SWS)
	Self-study per semester: 120 h • 80 h: pre- and post lecture studying and revision • 40 h: exam preparation
Prerequisites	Linear Algebra, Basic Probability Theory, Basic Knowledge of Propositional Logic,
Aim of module	The course provides an introduction to methods for AI-based decision making as a basis for the design of automated decision making and decision support systems. The course will cover the following topics: • Decision Problems and Bounded Rationality • Propositional Logic • Probability Theory • Probabilistic Graphical Models • Utility and Decision Theory • Game Theory • Markov Decision Processes • Reinforcement Learning
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire basic knowledge of the techniques, opportunities, and applications of AI-based decision making. (MK1, MF1)
	<u>Methodological competence:</u> Successful participants will be able to identify opportunities for decision support in an enterprise environment, select and apply appropriate techniques, and interpret the results. (MK2, MF3, MF4, MKO1)
	<u>Personal competence:</u> none
Media	Lecture videos, slide set, exercise sheets, software tools
Literature	S. Russel and P. Norvig: AI a modern Approach (3rd Edition), 2010 (selected sections)

Methods	The course consists of a lecture accompanied by practical homework and case studies. In the lecture, the students' basic concepts and methods of decision theory will be explained both in theory and using concrete examples. The students will practice and test their knowledge acquired in the lecture in homework assignments. Within the case studies, students model real world decision problems and try to solve them optimally using methods from the lecture.
Form of assessment	Written exam
Admission requirements for assessment	Midterm exam: 45 minutes (propositional logic and probability theory)
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Heiner Stuckenschmidt
Person in charge	Prof. Dr. Heiner Stuckenschmidt
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science,
Semester	$1^{st}/2^{nd}$ semester

IE 671	**Web Mining**
Form of module	Lecture and Exercise
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester: 28 h (2 SWS)
	Self-study: 56 h per semester • 31 h: pre and post lecture studying and revision • 25 h: examination and presentation preparation
Prerequisites	IE 500 Data Mining I (recommended). Fundamental notions of linear algebra and probability theory.
Aim of module	The vast amounts of textual content and structured data found on the Web provide us with a goldmine of data that can be mined to derive knowledge about nearly every aspect of human life. The course covers techniques for extracting knowledge from Web content as a basis for business decisions and applications. The course will cover the following topics: Web Usage Mining (including Recommender Systems), Web Structure Mining (including Social Network Analysis), and Web Content Mining (including Sentiment Analysis and Hate Speech Detection). NOTE: It is highly recommended to attend the module "Web Mining Project" in the same semester since the schedule and topics of both modules are aligned.
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire knowledge of the techniques, opportunities, and applications of Web mining. (MK1, MF1)
	<u>Methodological competence:</u> Successful participants will be able to identify opportunities for mining knowledge from Web content, select and apply appropriate techniques and interpret the results. (MK2, MF3, MF4)
	<u>Personal competence:</u>
Media	slide set, exercise sheets, data sets for the exercises
Literature	• Bing Liu: Web Data Mining. 2nd Edition, Springer, 2011. • Wouter de Nooy, et al.: Exploratory Social Network Analysis with Pajek. 2nd Edition, Cambridge University Press, 2011. • Bing Liu. Sentiment Analysis and Opinion Mining, Morgan & Claypool Publishers, 2012.

Methods	The course consists of a lecture together with accompanying practical exercises as well as student team projects. In the exercises the participants will gather initial expertise in applying state of the art web mining tools.
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	60 minutes
Language	English
Offering	Spring semester: Not offered in FSS 26. Alternatively, IE 685 may be taken.
Lecturer	Prof. Dr. Christian Bizer
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1st/2nd/3rd semester

IE 675b	**Machine Learning**
Form of module	Lecture with exercises
Type of module	Specialization Course
Level	Master
ECTS	9
Workload	In presence: 63 h (4+2 SWS)
	Exercises, assignments, and self-study: 167 h
Prerequisites	IE 500 Data Mining I (recommended) probability/linear algebra
Aim of module	Machine learning is concerned with building computer systems that improve with experience as well as the study of learning processes, including the design of algorithms that are able to make predictions or extract knowledge from data. The aim of this module is to provide an introduction into the field of machine learning, and study algorithms, underlying concepts, and theoretical principles. Topics include: • Basics of machine learning • Inference and decision • Selected classification and regression models • Parameter estimation • Dimensionality reduction (SVD, PCA, FA) • Mixture models and EM • Kernels and vector machines • Hyperparameter optimization
Learning outcomes and qualification goals	<u>Expertise:</u> • Deep understanding of algorithms and underlying concepts of machine learning (MK1, MF1)
	<u>Methodological competence:</u> • Being able to apply machine learning techniques and systems for a given problem • Being able to model and implement new machine learning techniques (MK2, MF3, MF4)
	<u>Personal competence:</u> • writing skills • presentation skills • statistical programming skills (MKO3, MF2)
Media	Slide set, exercise sheets, software, datasets
Literature	• K.P. Murphy. *Probabilistic Machine Learning: An Introduction*. The MIT Press, 2022

	• I. Goodfellow, Y. Bengio, A. Courville. *Deep Learning*, The MIT Press, 2017 • Additional material and articles provided in lecture notes
Methods	The course consists of a lecture accompanied by theoretical and practical exercises as well as case studies with real data. In the exercises, students will deepen the material discussed in the lecture, apply the methods in practice, and present the result.
Form of assessment	Written examination
Admission requirements for assessment	Homework assignments (pass at least 3 assignments)
Duration of assessment	120 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Rainer Gemulla
Person in charge	Prof. Dr. Rainer Gemulla
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	1st/2nd/3rd semester

IE 678	**Deep Learning**
Form of module	Lecture with exercises
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester: 42h (2+2 SWS)
	Exercises, assignments, and self-study: 119 h
Prerequisites	IE 675b Machine Learning or equivalent
Aim of module	Machine learning is concerned with building computer systems that improve with experience as well as the study of learning processes, including the design of algorithms that are able to make predictions or extract knowledge from data. Building upon IE 675b Machine Learning, this course focuses on deep learning and introduces basic and advanced deep learning architectures and techniques, training methods and hyperparameter optimization, as well as selected applications. Topics include: • Feedforward neural networks • Backpropagation and parameter optimization • Machine learning systems • Training techniques for deep learning models • Recurrent neural networks • Convolutional neural networks • Attention and Transformers • Deep learning for graphs • Deep generative modelling
Learning outcomes and qualification goals	Expertise:
	• Deep understanding of fundamental concepts, models, and algorithms of deep learning (MK1, MF1)
	<u>Methodological competence:</u> • Being able to build and train deep learning models • Being able to select suitable deep learning techniques for a given learning problem (MK2, MF3, MF4)
	<u>Personal competence:</u> • writing skills • presentation skills • statistical programming skills (MKO3, MF2)
Media	Slide set, exercise sheets, software, datasets

Literature	• I. Drori. *The Science of Deep Learning*. Cambridge University Press, 2023 • I. Goodfellow, Y. Bengio, A. Courville. *Deep Learning*, The MIT Press, 2017 • K.P. Murphy. *Probabilistic Machine Learning: An Introduction*. The MIT Press, 2022 • K.P. Murphy. *Probabilistic Machine Learning: Advanced Topics*. The MIT Press, 2023 • Additional material and articles provided in lecture notes
Methods	The course consists of a lecture accompanied by theoretical and practical exercises as well as case studies with real data. In the exercises, students will deepen the material discussed in the lecture, apply the methods in practice, and present the result.
Form of assessment	Oral examination
Admission requirements for assessment	Homework assignments (pass at least 2 assignments)
Duration of assessment	25 minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Magret Keuper
Person in charge	Prof. Dr. Rainer Gemulla
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	2nd/3rd semester

IE 684	**Web Mining Project**
Form of module	Project
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester: 28 h (2 SWS)
	Self-study: 56 h per semester • 36 h: project work • 20 h: report writing and presentation preparation
Prerequisites	Programming skills in Java or Python. IE 671 Web Mining (recommended).
Aim of module	The Web Mining project allows students to apply the methods and techniques that they have learned in the lecture Web Mining in the context of a practical integration project. The projects can cover any of the topic of Web usage, content or structure mining. NOTE: It is highly recommended to attend the module IE 671 "Web Mining" in the same semester since the schedule and topics of both modules are aligned.
Learning outcomes and qualification goals	<u>Expertise:</u> • Students will be able to identify opportunities for employing Web Mining techniques in business applications and will learn to apply appropriate techniques for mining Web data. (MK1, MF1)
	<u>Methodological competence:</u> • Participants will acquire practical knowledge of techniques for mining Web data. • Project organization skills (MK2, MF3, MF4, MKO3)
	<u>Personal competence:</u> • Presentation skills • Team work skills (MKO2, MF2)
Media	Slide set with references to potential topics, datasets, etc.
Literature	• Bing Liu: Web Data Mining. 2nd Edition, Springer, 2011. • Wouter de Nooy, et al.: Exploratory Social Network Analysis with Pajek. 2nd Edition, Cambridge University Press, 2011. • Bing Liu. Sentiment Analysis and Opinion Mining, Morgan & Claypool Publishers, 2012.

Methods	Students work on their projects in teams and report about the results of their projects in the form of a written report as well as an oral presentation.
Form of assessment	Project report (70%, 5-15 pages in length), oral project presentation (30%, 10-90 minutes).
Admission requirements for assessment	-
Duration of assessment	4-6 weeks (execution of the project work and writing of the report), 10-90 minutes (presentation).
Language	English
Offering	Spring semester: Not offered in FSS 26. Alternatively, IE 686 may be taken.
Lecturer	Prof. Dr. Christian Bizer
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Mannheim Master in Data Science Lehramt Informatik, MMSDS
Semester	1. /2. /3. Semester

IE 686	**Large Language Models and Agents**
Form of module	Project
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester: 28 h (2 SWS) Self-study: 56 h per semester • 36 h: project work • 20 h: report writing and presentation preparation
Prerequisites	• Programming skills in Python • Basic machine learning concepts and techniques
Aim of module	Large language models (LLMs) such as GPT, Claude, Llama, Gemini, and Mistral have the potential to enable a wide range of new applications and to significantly improve the performance of existing systems. The course introduces students to LLMs and teaches them how to employ the models within applications. The course covers the following topics: • Introduction to LLMs • Instruction tuning and reinforcement learning from human feedback • Prompt engineering and efficient adaptation • Evaluation of LLMs and agents • Development of LLM-based applications
Learning outcomes and qualification goals	<u>Expertise:</u> Students will understand the principles of training LLMs. They will be able to identify opportunities for employing LLMs in business applications and will learn to apply prompt engineering techniques as well as agent frameworks for solving business tasks. (MK1, MF1)
	<u>Methodological competence:</u> Participants will acquire theoretical and practical knowledge on large language models, prompt engineering techniques, and agents. They will learn to use frameworks like LangGraph and AutoGen for the design and implementation of the learned concepts in practical use cases. (MK2, MF3, MF4, MKO3)
	<u>Personal competence:</u> • Project organization skills • Presentation skills • Teamwork skills • Python programming skills

	(MKO1, MKO2, MF2)
Media	Slide sets, software, datasets
Literature	• Zhou et al.: A Comprehensive Survey on Pretrained Foundation Models: A History from BERT to ChatGPT, 2024, International Journal of Machine Learning and Cybernetics. • Zhao et al.: A Survey of Large Language Models, 2024, arXiv:2303.18223. • Wang et al.: A Survey on Large Language Model Based Autonomous Agents, 2024, Frontiers of Computer Science.
Methods	The course participants gain knowledge about the principles and methods behind large language models through lectures and tutorials. In the second half of the course, students apply their knowledge in team projects and will report about their results in the form of a written report as well as an oral presentation.
Form of assessment	Project report (70%), oral project presentation (30%)
Admission requirements for assessment	-
Duration of assessment	-
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Christian Bizer Ralph Peeters
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	It is highly recommended to attend the course IE 685 Large Language Models and Agents Lecture in the same semester as this course as the schedules of both courses are aligned to each other.
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Mannheim Master in Social Data Science, Lehramt Informatik
Semester	1st/2nd/3rd semester

IE 694	**Artificial Intelligence Applications in Industry**
Form of module	Lectures and accompanying Tutorials
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 h (2 + 2 SWS)
	Self-study: 124 h per semester Including the creation of a learning portfolio
Prerequisites	Necessary Knowledge: • Machine Learning Concepts and Techniques • Programming in Python
Aim of module	Participants will learn about the use of Artificial Intelligence methods, mostly from the field of machine learning in different sectors and industries. They will learn about application areas in the primary, secondary and tertiary sector, get an introduction to examples of such applications that have been published on a scientific level and gather some experience in working with data from the respective fields using publically available datasets.
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire knowledge about possible applications of machine learning in different branches of industry as well as the dominant methods used in these areas. (MK2, MK3)
	<u>Methodological competence:</u> Successful participants will be able to: • Identify potential for applying AI methods in different areas of industry; • Decide on a suitable method for addressing typical problems in these industries (MF2)
	<u>Personal competence:</u> Participants will learn to reflect and document their own learning process (MKO2)
Media	Slides, Data Sets, Software Tools.
Literature	Various Scientific Publications – details in the lecture slides
Methods	Lectures, tutorials, independent study
Form of assessment	Learning Portfolio
Admission requirements for assessment	n/a

Duration of assessment	Continuous assessment throughout the module (learning portfolio).
Language	English
Offering	FSS
Lecturer	Prof. Dr. Heiner Stuckenschmidt
Person in charge	Prof. Dr. Heiner Stuckenschmidt
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Mannheim Master in Data Science, MMSDS
Semester	2.-4.

IE 695	**Reinforcement Learning**
Form of module	Lecture with Exercise (partially online)
Type of module	Data Analytics Methods
Level	Master
ECTS	6
Workload	Hours per semester present: 56 (4 SWS)
	Self-study: 98h (70h lectures/exercises, 28h exam preparation
Prerequisites	Machine Learning / Computer Vision /Generative Computer Vision Models course, theoretical and practical knowledge of neural networks
Aim of module	• Basic concepts of reinforcement learning: MDP, policies, on-policy, off-policy learning • Classical tabular reinforcement learning, DP, Policy Iteration, Q-Learning, SARSA, Monte-Carlo methods • Function approximation for reinforcement learning • Policy gradient methods
Learning outcomes and qualification goals	<u>Expertise:</u> After the course students will understand classical concepts of reinforcement learning as well as state of the art algorithms.
	<u>Methodological competence:</u> The students are able to understand and customize popular reinforcement learning algorithms, choose the right setting for their problem and train agents to perform well in environments with which they interact.
	<u>Personal competence:</u> The course trains abstract thinking and the ability to formally model application scenarios. By solving assigned exercises independently, the transfer of the learned material to related questions is promoted.
Media	Exercise sheets and lecture slides available online, blackboard
Literature	• Sutton & Barto: Reinforcement learning: an introduction, 2018
Methods	Lecture, exercises every two weeks, book studies
Form of assessment	written examination
Admission requirements for assessment	-
Duration of assessment	90 min.
Language	English
Offering	HWS
Lecturer	Prof. Dr.-Ing. Margret Keuper
Person in charge	Prof. Dr.-Ing. Margret Keuper
Duration of module	1 Semester

Further modules	
Range of application	Msc Business Informatics, Msc Data Science, Lehramt Informatik
Semester	1./2./3. Semester

IE 696	**Advanced Methods in Text Analytics**
Form of module	Lecture with exercises
Type of module	Specialization course
Level	Master
ECTS	6
Workload	Hours per semester: 56 h (4 SWS)
	Self-study: 112 h per semester • 84 h: pre and post lecture studying and revision • 28 h: examination preparation
Prerequisites	Fundamental notions of linear algebra and probability theory. Successful completion of “Text Analytics” (IE661), “Machine Learning” (IE675b) or “Deep Learning” (IE678).
Aim of module	This module builds upon the introduction to Natural Language Processing (NLP) from “Text Analytics” (IE661) and introduces students to cutting-edge problems, techniques, and state-of-the-art methods in NLP. The course will focus on neural models of meaning in context and present a variety of “Deep Learning” architectures for different applications in human language technology (e.g., summarization, dialogue systems and machine translation). Moreover, we will cover open research areas, such as the explainability and interpretability of NLP models and methods to quantify the degree of bias they exhibit.
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire knowledge of state-of-the-art principles and methods of Natural Language Processing, specifically focusing on applying statistical methods to human language technologies. (MK1, MK2, MF3)
	<u>Methodological competence:</u> Successful participants will be able to understand state-of-the-art methods for Natural Language Processing and select, apply and evaluate the most appropriate techniques for various practical and application-oriented scenarios. (MF3)
Media	Lecture and tutorial slides, exercise sheets
Literature	Dan Jurafsky and James H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition (3rd edition, online available at https://web.stanford.edu/~jurafsky/slp3/).
Methods	Lectures, tutorials
Form of assessment	Written examination

Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Simone Paolo Ponzetto; Dr. Daniel Ruffinelli
Person in charge	Prof. Dr. Simone Paolo Ponzetto
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, MMDS, MMSDS, Lehramt Informatik
Semester	1st/2nd/3rd semester

IE 698	**Foundations and Applications of Digital Health Technologies**
Form of module	Lecture
Type of module	Specialization Course
Level	Master
ECTS	3
Workload	Hours per semester in presence: 28 h per semester Self-study: 56 h per semester
Prerequisites	Necessary: Basic knowledge about AI systems (knowledge-based systems, machine learning, deep neural networks) Optional: • Participation of Lecture "Responsible AI" Winter Term 2023/24 • Basic knowledge about digital health systems
Aim of module	Conceptual foundations: • Understanding of important concepts in digital health (eHealth, mHealth, telehealth, digital phenotyping, digital twins, and other concepts) Methods: • e.g., interviewing, group discussions, design research methods (prototyping, design thinking, co-design), (digital) ethnography Applications: • AI in digital health apps in medicine and healthcare • AI-based robots • AI-based VR systems
Learning outcomes and qualification goals	Knowledge: Students gain insights and understanding of important concepts in digital health. They learn modes of transdisciplinary thinking and theorizing on digital health. (MK1)
	Capabilities: Students learn elements of mixed-methods study design for digital health research and co-design methodology and learn to assess scientific publications in this domain critically. (MF1 and MF2)
	Competencies: Students learn to critically assess the conceptual, technical, ethical, legal, and social aspects of digital health applications. (MKO1)
Media	Slides and supporting media will be available online.

Literature	• Fagherazzi, G. Deep Digital Phenotyping and Digital Twins for Precision Health: Time to Dig Deeper. Journal of Medical Internet Research 22, e16770 (2020). https://www.jmir.org/2020/3/e16770/ • Hahn, H. & Schreiber, A. E-Health. in Digital Transformation (ed. Neugebauer, R.) 311–334 (Springer Berlin Heidelberg, 2019). https://doi.org/10.1007/978-3-662-58134-6_19 • Budd, J. et al. Digital technologies in the public-health response to COVID-19. Nat Med 26, 1183–1192 (2020). https://www.nature.com/articles/s41591-020-1011-4 • Voeneky, S., P. Kellmeyer, O. Mueller, and W. Burgard, ed. 2022. The Cambridge Handbook of Responsible Artificial Intelligence: Interdisciplinary Perspectives. Cambridge Law Handbooks. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781009207898 (open source)
Methods	Interactive lecture
Form of assessment	Written exam
Admission requirements for assessment	-
Duration of assessment	45 min
Language	English
Offering	Spring semester
Lecturer	Jun.-Prof. Dr. Philipp Kellmeyer
Person in charge	Jun.Prof. Dr. Philipp Kellmeyer
Duration of module	1 Semester
Further modules	Lecture on Responsible AI, Fall 2024
Range of application	Msc Business Informatics, Msc Data Science, Lehramt Informatik
Semester	All semesters possible

IE 699	**Co-creating digital health applications with design methodology**
Form of module	Excercise
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester in presence: 56 h Self-study: 112 h
Prerequisites	Necessary: Basic knowledge about AI systems (knowledge-based systems, machine learning, deep neural networks) Optional: • Participation of Lecture "Responsible AI" Winter Term 2023/24 • Basic knowledge about digital health systems
Aim of module	Conceptual foundations: Understanding of important concepts in digital health (eHealth, mHealth, telehealth, digital phenotyping, digital twins, and other concepts) Methods: Interviewing, group discussions, design research methods (prototyping, design thinking, co-design), (digital) ethnography Applications: By-design approaches to developing digital health apps and other solutions.
Learning outcomes and qualification goals	Knowledge: Along with digital health use cases, they learn basic by-design principles for developing digital health applications. (MK1)
	Capabilities: Students learn elements of mixed-methods study design for digital health research and co-design methodology via design fictions and mockups developed in groups in the exercise. (MF1, MF2, MF3)
	Competencies: Students learn to apply their knowledge and capabilities regarding by-design approaches to solve specific problems in a team context. (MKO1)
Media	Slides and supporting media will be available online.
Literature	• Fagherazzi, G. Deep Digital Phenotyping and Digital Twins for Precision Health: Time to Dig Deeper. Journal of Medical Internet Research 22, e16770 (2020). https://www.jmir.org/2020/3/e16770/ • Hahn, H. & Schreiber, A. E-Health. in Digital Transformation (ed. Neugebauer, R.) 311–334 (Springer Berlin Heidelberg, 2019). https://doi.org/10.1007/978-3-662-58134-6_19

	• Budd, J. et al. Digital technologies in the public-health response to COVID-19. Nat Med 26, 1183–1192 (2020). https://www.nature.com/articles/s41591-020-1011-4 • Voeneky, S., P. Kellmeyer, O. Mueller, and W. Burgard, ed. 2022. The Cambridge Handbook of Responsible Artificial Intelligence: Interdisciplinary Perspectives. Cambridge Law Handbooks. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781009207898 (open source)
Methods	Excercise
Form of assessment	Presentation in course
Admission requirements for assessment	-
Duration of assessment	20 min (15 min. Presentation, 5 min Q&A)
Language	English
Offering	Spring semester
Lecturer	Jun.-Prof. Dr. Philipp Kellmeyer
Person in charge	Jun.Prof. Dr. Philipp Kellmeyer
Duration of module	1 Semester
Further modules	Lecture on Responsible AI, Fall 2024
Range of application	Msc Business Informatics, Msc Data Science, Lehramt Informatik
Semester	All semesters possible

CS 646	**Higher Level Computer Vision**
Form of module	Lecture with Exercise
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 (4SWS)
	Self-study: 98h • 70h lecture/exercises • 28h exam preparation
Prerequisites	Basis skills in linear algebra, basis knowledge in python and pytorch
Aim of module	• Point Features and point matching • Object Identification • Deep Learning for Computer Vision • Object Detection • Image Segmentation • Optical Flow • Video and Motion Segmentation
Learning outcomes and qualification goals	<u>Expertise:</u> The students have a detailed understanding of Computer Vision techniques. They can evaluate given Computer Vision algorithms. (MK1, MK2, MF1, MF3)
	<u>Methodological competence:</u> Students understand the technical basis of Computer Vision algorithms; they can explain the discussed methods and implement them. (MF1, MF2, MF3)
	<u>Personal competence:</u> Understanding complex Computer Vision problems; thorough judgment in the design and use of methods; can work efficiently in a team. (MK01, MK02)
Media	Exercise sheets and lecture slides are available online.
Literature	• Goodfellow et al..: Deep Learning, MIT Press, 2016. https://www.deeplearningbook.org/ • R. Szeliski: Computer Vision Algorithms and Applications, Springer, 2010. ISBN: 978-1-84882-934-3. (Online available: http://szeliski.org/Book/ • D. Forsyth, J. Ponce: Computer Vision: A Modern Approach, Prentice Hall, 2nd edition, 2012. ISBN: 978-0136085928 (Online available: http://cmuems.com/excap/readings/forsyth-ponce-computer-vision-a-modern-approach.pdf

	• R. Hartley, A. Zisserman: Multiple View Geometry in Computer Vision, Cambridge University Press, 2nd edition, 2004.
Methods	Lecture, weekly exercise, book studies, implementation of algorithms, visualization of results
Form of assessment	written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes (written)
Language	English
Offering	Fall semester
Lecturer	Professor Dr.-Ing. Margret Keuper
Person in charge	Professor Dr.-Ing. Margret Keuper
Duration of module	1 Semester
Further modules	Image Processing, Generative Computer Vision Models
Range of application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	$1^{st}/2^{nd}/3^{rd}$ semester

CS 647	**Image Processing**
Form of module	Lecture with Exercise (partially online)
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 (4SWS)
	Self-study: 98h • 70h lecture/exercises • 28h exam preparation
Prerequisites	Basis skills in linear algebra, basis knowledge in python
Aim of module	• Introduction to Imaging (human visual system, optics, sensors) • Noise and basic operations (convolution, correlations, gradients) • Energy minimization • Variational Methods • Feature extraction • Classification • Segmentation • Stereo Vision
Learning outcomes and qualification goals	<u>Expertise:</u> The students have a detailed understanding of image and video processing techniques. They can evaluate given image processing algorithms. (MK1, MK2, MF1, MF3)
	<u>Methodological competence:</u> Students understand the technical basis of image processing algorithms; they can explain the discussed methods and implement them. (MF1, MF2, MF3)
	<u>Personal competence:</u> Understanding complex Image Processing problems; thorough judgment in the design and use of methods; can work efficiently in a team. (MK01, MK02)
Media	Exercise sheets and lecture slides available online.
Literature	• R. Szeliski: Computer Vision Algorithms and Applications, Springer, 2010. ISBN: 978-1-84882-934-3. (Online available: http://szeliski.org/Book/) • D. Forsyth, J. Ponce: Computer Vision: A Modern Approach, Prentice Hall, 2nd edition, 2012. ISBN: 978-0136085928
Methods	Lecture, weekly exercise, book studies, implementation of algorithms, visualization of results

Form of assessment	written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Spring Semester
Lecturer	Professor Dr.-Ing. Margret Keuper
Person in charge	Professor Dr.-Ing. Margret Keuper
Duration of module	1 Semester
Further modules	Higher Level Computer Vision, Generative Computer Vision Models
Range of application	B. Sc. Wirtschaftsinformatik, M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	$1^{st}/2^{nd}/3^{rd}$ semester

CS 668	**Generative Computer Vision Models**
Form of module	Lecture with Exercise
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 (4SWS)
	Self-study: 98h • 70h lecture/exercises • 28h exam preparation
Prerequisites	Basis skills in linear algebra, basis knowledge in python/pytorch
Aim of module	• Introduction to Clustering and Unsupervised Learning • Introduction to Generative Models • Autoregressive Models for Image Generation • (Normalizing) Flow • Latent Variable Models • Latent Space Visualizations • Generative Adversarial Models • Diffusion Models • Multi-Modal Conditioning
Learning outcomes and qualification goals	<u>Expertise:</u> The students have a detailed understanding of image generation techniques, latent variable models, and their evaluations. (MK1, MK2, MF1, MF3)
	<u>Methodological competence:</u> Students understand the technical basis of generative models; they can explain the discussed methods and implement them. (MF1, MF2, MF3)
	<u>Personal competence:</u> Understanding image generative models, their working principles and training procedures; thorough judgment in the design and use of methods; Students can work efficiently in a team. (MK01, MK02)
Media	Exercise sheets and lecture slides available online.
Literature	Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, An MIT press book, 2016.
Methods	Lecture, weekly exercise, book studies, implementation of algorithms, visualization of results
Form of assessment	Written
Admission requirements for assessment	-
Duration of assessment	90 minutes

Language	English
Offering	Spring Semester
Lecturer	Professor Dr.-Ing. Margret Keuper
Person in charge	Professor Dr.-Ing. Margret Keuper
Duration of module	1 Semester
Further modules	Higher Level Computer Vision
Range of application	M. Sc. Wirtschaftsinformatik, M. Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1st/2nd/3rd semester

E. Responsible Data Science

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
CS 652	Data Security and Privacy	FSS	E	6	85
	Legal and Ethical Aspects of Privacy	HWS	E	3	87
CS 718	AI and Data Science in Fiction and Society	HWS	E	4	89
AC 654	Additional Course – Responsible Data Science	HWS/FSS	E	Max 18	91
DS 203	Responsible AI: Conceptual Foundations, Methods and Applications	HWS	E	6	92

2. Detailed descriptions

CS 652	**Data Security and Privacy**
Form of module	Inverted classroom with exercises
Type of module	Fundamental in Computer Science
Level	Master
ECTS	6
Workload	Hours per semester present: 56h (4 SWS)
	Self-study: 112h
Prerequisites	There are no formal prerequisites but knowledge in cryptography or IT-security is recommended, e.g., by attending the lectures "Kryptographie I" or "Selected Topics in IT-Security"
Aim of module	Nowadays, users are more and more revealing data to the outside – either willingly as in the context of data mining or possibly unconsciously as in the case of the Internet of Things. The aim of the module is to raise awareness, in particular with respect to privacy violations. This is done by showing various security threats, e.g., traces left on the Internet such as the use of cookies or browser fingerprinting. In particular, the topic of privacy preservation will be covered. This includes discussing different approaches for defining the meaning of privacy but also possible countermeasures such as anonymization of data or the use of dedicated encryption schemes.
Learning outcomes and qualification goals	<u>Expertise:</u> Students will acquire the knowledge to identify security and privacy threats and to select and use appropriate countermeasures. (MK2)
	Methodological competence:
	Successful participants will be able to understand, to select, apply and evaluate the most appropriate techniques for a variety of different privacy-sensitive scenarios. In particular they are able to realize possible risks in new scenarios and to transfer given solutions to these. (MK1)
	<u>Personal competence:</u> The analytic, concentrated, and precise thinking of the students is trained. By the independent treatment of applications, e.g. in the course of the exercises, their abstraction capacity is further developed and the transfer of the learned material to related questions is trained. (MF1, MKO3)
Media	Video recordings, annotated lecture slides

Literature	Will be announced in the lecture
Methods	Reworking the lecture and studying the relevant literature in self-study. During the lecture: discussing questions and ideas and working together on concrete examples. Solving exercises in self-study and in practice in cooperation with fellow students.
Form of assessment	Written exam
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	FSS
Lecturer	Prof. Dr. Frederik Armknecht
Person in charge	Prof. Dr. Frederik Armknecht
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsinformatik, Lehramt Informatik, M.Sc. Mathematik
Semester	1st/2nd/3rd semester

	Legal and Ethical Aspects of Privacy
Form of module	Lecture
Type of module	Responsible Data Science
Level	Master
ECTS	3
Workload	Hours per semester present: 28 h (2 SWS) Self-study per semester: 60 h • Pre-and post-lecture studying and preparation (30h) • Examination preparation (30h)
Prerequisites	None
Aim of module	In a first section the course will acquaint the students with the origins and basic principles of privacy law mainly in Europe. Furthermore, it will contrast the European privacy foundations with the U.S. approach. At the core of this course stands the new European General Data Protection Regulation (GDPR) and its applicability to specific cases and basic principles. Moreover, the course will cover current challenges to the existing privacy paradigms by big data and big data analytics. In a second section the course will cover ethical aspects of the use of personal and non-personal data. Data potentially allows to identify and target individuals and offer individualized products to them. However, sometimes this kind of individualization might be legal, but the question arises whether it is also desirable from an ethical and societal point of view? The course will use selected examples (e.g., first-degree price discrimination) in order to illustrate the ambivalence of legality, legitimacy, and ethics. In this context, the use of artificial intelligence and its impact on privacy will be addressed.
Learning outcomes and qualification goals	Students will… • have a basic knowledge on the applicability of the General Data Protection Regulation (GDPR) and its basic principles; • be aware of privacy issues and potential legal limitations when processing data; • be aware of current challenges to the existing privacy • have an understanding why privacy issues are treated differently in Europe and the U.S.; • paradigms by big data and big data analytics; • be aware of currently discussed new approaches to privacy (e.g., privacy by design); • be aware of ethical issues of using personal as well as non-personal data

	• be aware of the chances and challenges the use of artificial intelligence will bring
Media	Video tutorials, lectures, online quizzes
Literature	Students will receive reading assignments for each unit together with the syllabus at the beginning of the semester.
Methods	The class will generally be conducted as a lecture. However, some of the sessions will be conducted on an inverted class-room principle. Students will be able to access the video lectures at the beginning of the semester. The content of these videos will be discussed along with additional reading in the individual class sessions.
Form of assessment	written examination
Admission requirements for assessment	Successful participation in 5 out of at least 7 online quizzes
Duration of assessment	90 minutes
Language	English
Offering	HWS
Lecturer	Prof. Dr. Egidy
Person in charge	Prof. Dr. Egidy
Duration of module	1 semester
Further modules	-
Range of application	MMDS
Semester	1st/2nd/3rd semester

CS 718	**AI and Data Science in Fiction and Society**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree
Aim of module	In this seminar, students analyze and discuss fictional works in the area of AI and data science with respect to technological and societal aspects. The present the results orally and in a written report.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> Students will learn about societal effects of AI and data science and become aware of potential threats and dangers, but also of chances of those new technologies. (MK1)
	<u>Methodological competence:</u> Students will develop methods and skills to find relevant literature for his/her topic, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF1, MF2, MF3)
	<u>Personal qualification:</u> Students will acquire skills on how to find relevant literature for a research topic, discuss a fictional work using secondary literature as background material, write a well-structured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MKO2)
Media	Fictional and non-fictional texts
Literature	A detailed literature list is compiled for each offering.
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member
Form of Assessment	Seminar paper (length: 15-20 pages depending on the topic), Peer Review (up to 10 pages), Presentation (20-30) minutes depending on the topic)
Admission requirements for assessment	-
Duration of Assessment	6-8 weeks (writing of the essay), 20-30 minutes (presentation).
Language	English

Offering	Fall semester
Lecturers	Prof. Dr. Heiko Paulheim and research staff members
Person in charge	Prof. Dr. Heiko Paulheim
Duration of module	1 semester
Further modules	-
Range of Application	MMDS, M. Sc. Wirtschaftsinformatik, Lehramt für Gymnasien
Semester	3. Semester

AC 654	**Additional Course – Responsible Data Science**
Form of module	Depends on course
Level	Master
ECTS	Max. 18
Workload	Depends on course
Prerequisites	Depends on course
Aim of module	The course falls into the responsible data science area of the MMDS and covers topics related to responsible data science but is not directly equivalent to any course in the MMDS module catalogue. The course level equals a regular course in MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.
Learning outcomes and qualification goals	Depends on course
Media / Literature / Methods / Form and duration of assessment	Depends on course
Language	English preferred, but any other language possible if Mannheim faculty member is able to identify content and level
Offering	Spring semester / Fall semester
Lecturer	Lecturer at the host university
Person in charge	Lecturer at the host university
Duration of module	1 Semester
Further modules	-
Range of application	MMDS
Semester	$2^{nd}/3^{rd}/4^{th}$ semester

DS 203	**Responsible AI: Conceptual Foundations, Methods and Applications**
Form of module	Lecture with Essay
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester in presence: 28 (2 SWS) Self-study: 56 h lectures; 20 h essay / preparation oral exam
Prerequisites	Basic knowledge about AI systems (knowledge-based systems, machine learning, deep neural networks)
Aim of module	Conceptual foundations: • understanding of important concepts in human-AI interaction and AI ethics (such as trust, autonomy, responsibility) Methods: • e.g., narrative interviews, group discussions, design research methods (prototyping, design thinking, techno-mimesis), (digital) ethnography, participatory action research Applications: • AI in medicine and healthcare • Social robotics • Generative AI • other use cases / real-world AI applications
Learning outcomes and qualification goals	Expertise: Students gain insights and understanding of important concepts in human-AI interaction and AI ethics. They learn modes of transdisciplinary thinking and theorizing. Along sector-specific use cases they learn about ethical, legal and social aspects and challenges of real-world AI application, e.g. for healthcare.
	Methodological competence: Students learn elements of mixed-methods study design for human-AI interaction research
	Personal competence: Students learn to critically assess conceptual, ethical, legal and social aspects of human-AI interaction. They gain skills in transdisciplinary research and theory-building and learn to transfer these insights to real-world human-AI interaction scenarios.
Media	Slides are available online
Literature	• Voeneky, S., P. Kellmeyer, O. Mueller, and W. Burgard, ed. 2022. The Cambridge Handbook of Responsible Artificial Intelligence: Interdisciplinary Perspectives. Cambridge Law Handbooks. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781009207898 (open source)

	• Coeckelbergh, Mark. AI ethics. (2020). The MIT Press. https://www.gbv.de/dms/bowker/toc/9780262538190.pdf • Heilinger, J.-C. (2022). The Ethics of AI Ethics. A Constructive Critique. Philosophy & Technology, 35(3), 61. https://doi.org/10.1007/s13347-022-00557-9 • McLennan, S., Fiske, A., Tigard, D., Müller, R., Haddadin, S., & Buyx, A. (2022). Embedded ethics: A proposal for integrating ethics into the development of medical AI. BMC Medical Ethics, 23(1), 6. https://doi.org/10.1186/s12910-022-00746-3 • Schmitt, L. (2021). Mapping global AI governance: A nascent regime in a fragmented landscape. AI and Ethics. https://doi.org/10.1007/s43681-021-00083-y
Methods	Interactive lecture
Form of assessment	Essay
Admission requirements for assessment	--
Duration of assessment	Essays need to be handed in by December 8th
Language	English
Offering	Fall semester
Lecturer	JProf. Dr. Philipp Kellmeyer
Person in charge	JProf. Dr. Philipp Kellmeyer
Duration of module	1 Semester
Further modules	Follow-up (block) seminar planned for summer semester 2024
Range of application	Msc Business Informatics, Msc Data Science, Lehramt Informatik
Semester	All semesters possible

F. Projects and Seminars

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
AC 653	Additional Course – Projects and Seminars	HWS/FSS	E	Max. 18	95
TP 500	Team Project	HWS/FSS	G/E	12	96
IP 500	Individual Project	HWS/FSS	G/E	8	98
SQ 500	Scientific Research	Irregular	E	2	100
CS 701	Seminar Selected Topics in Algorithmics and Cryptography	Irregular	E	4	102
CS 704	Master Seminar Artificial Intelligence	Irregular	E	4	104
CS 707	Data Analytics Seminar	Irregular	E	4	106
CS 708	Seminar Software Engineering	Irregular	E	4	108
CS 709	Seminar Text Analytics	Irregular	G/E	4	110
CS 710	Seminar Prof. Paulheim	Irregular	G/E	4	112
CS 715	Seminar Large Scale Data Integration	Irregular	E	4	114
CS 716	Seminar Prof. Armknecht	Irregular	E	4	116
CS 717	Master Seminar on Computer	HWS/FSS	E	4	118
CS 720	Uncertainty Estimation	Irregular	E	4	120
CS 721	Seminar Data-Science I	Irregular	E	4	122
IE 704	Seminar AI Systems Engineering	Irregular	E	4	124
IS 752	Seminar on Process and Management Analytics	FSS	E	4	MMM*
IS 723	Seminar Data-Science II (Empirical Studies)	HWS	E	4	MMM*
MAS 515	Seminar Mathematische Optimierung	Irregular	D	4	126

* For a detailed description, please see the module catalogues of the respective following degree programs:

- MMM: Mannheim Master in Management
  https://www.bwl.uni-mannheim.de/studium/master/mmm/#c176637

2. Detailed descriptions

AC 653	**Additional Course – Projects and Seminars**
Form of module	Depends
Level	Master
ECTS	Max. 18
Workload	Depends
Prerequisites	Depends
Aim of module	The course equals a seminar in the MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.
Learning outcomes and qualification goals	Depends on course
Media / Literature / Methods / Form and duration of assessment	Depends
Language	English preferred, but any other language possible if Mannheim faculty member is able to identify content and level
Offering	Spring semester / Fall semester
Lecturer	Lecturer at the host university
Person in charge	Lecturer at the host university
Duration of module	1 Semester
Further modules	-
Range of application	MMDS
Semester	$2^{nd}/3^{rd}/4^{th}$ semester

TP 500	**Team Project**
Form of module	Project
Type of module	Team Project
Level	Master
ECTS	12 in two consecutive semesters or 12 in one semester
Workload	Hours per semester: 12 month-project: 28 h (2 SWS) 6 month-project: 56 h (4 SWS)
	Self-study: 140 h per semester (12 month project); • 112 h: pre and post lecture studying, revision and free self-study • 28 h: preparation of examination/presentation Self-study: 280 h per semester (6 month project) • 224 h: pre and post lecture studying, revision and free self-study • 56 h: preparation of examination/presentation
Prerequisites	Depends on topic
Aim of module	The students solve a practical problem as a team. The participants have to analyze and refine the problem and come up with a project plan for developing a concrete solution that will be carried out by the team over the duration of a whole year. Concrete topics for projects are defined by the supervisors and offered to the students who can apply for different topics. Problem area and techniques involved depend on the expertise of the offering chair.
Learning outcomes and qualification goals	Depending on the actual topic of the project, participants will acquire • in depths knowledge in a certain application of business informatics and data science • knowledge about methods and technologies typically applied in the application area • knowledge about practical problems and challenges when applying a certain technique in a given application area (MK1, MK2, MK3) Participants will learn to • refine a given problem statement by analyzing requirements and the state of the art using techniques like literature research and expert interviews. • Define a workplan including tasks, milestones, deliverables and resources and continually assess and modify the plan according to the actual progress of the work. (MF1, MF2, MF3, MF4)

	Being a team effort, the project explicitly targets personal competence in terms of • working in and managing a team of experts possibly from different academic and cultural backgrounds • taking part in discussions and learning to contribute the own opinion without overruling other opinions • self-management and responsibility within the requirements of collaborative work (MKO1, MKO2, MKO3)
Media	Depends on project
Literature	Depends on topic
Methods	Team-discussions, Presentations, Teamwork, Individual preparation of empirical contributions; self-study
Form of assessment	One or more reports totaling 50 - 120 pages (depending on the topic) and presentation (10-90 minutes).
Admission requirements for assessment	• 12-month project: withdrawal within the first 6 weeks possible without failing • 6-month project: withdrawal within the first 3 weeks possible without failing
Duration of assessment	Final report (length: one of more reports totalling 50-120 pages depending on the topic), presentation (10-90 minutes depending on the topic).
Language	English
Offering	Spring semester/Fall semester
Lecturer	Professors of the School of Business Informatics and Mathematics or of the Area Information Systems of the Business School
Person in charge	Professors of the Institute of Computer Science and Business Informatics or of the Area Information Systems of the Business School
Duration of module	1 semester or 2 semesters
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	1st/2nd/3rd semester

IP 500	**Individual Project**
Form of module	Project
Type of module	Individual Project
Level	Master
ECTS	8
Workload	Self study: 240 h per semester
Prerequisites	Depends on topic
Aim of Modules	The student solves a practical problem individually. The student has to analyse and refine the problem and come up with a project plan for developing a concrete solution. Concrete topics for projects are defined by the supervisors and offered to the students who can apply for different topics. Problem area and techniques involved depend on the expertise of the offering chair.
Learning outcomes and qualifications goals	Depending on the actual topic of the project, participants will acquire • in-depth knowledge in a certain application of data science • knowledge about methods and technologies typically applied in the application area knowledge about practical problems and challenges when applying a certain technique in a given application area (MK1, MK2, MK3)
	Participants will learn to • refine a given problem statement by analysing requirements and the state of the art using techniques like literature research and expert interviews. • define a workplan including tasks, milestones, deliverables and resources and continually assess and modify the plan according to the actual progress of the work. (MF1, MF2, MF3, MF4, MKO3)
Media	Depends on project
Literature	Depends on topic
Methods	Self-study, presentations
Form of Assessment	Final report (length: 10-50 pages depending on the topic), presentation (15-30 minutes depending on the topic).
Admission requirements for assessment	-
Duration of Assessment	6 months (execution of the project and writing of the report), 15-30 minutes (presentation).
Language	English/German
Offering	Irregular

Lecturer	Professors of the Institute of School of Business Informatics and Mathematics or of the School of Social Sciences
Person in Charge	Professors of the Institute of School of Business Informatics and Mathematics of the School of Social Sciences
Duration of module	1 semester
Further modules	-
Range of Applications	MMDS
Semester	1st/2nd/3rd semester

SQ 500	**Scientific Research**
Form of module	Inverted Classroom with Exercises
Type of module	Key Qualification
Level	Master
ECTS	2
Workload	80% (48 hours) self-study and 20% (12 hours) coursework
Prerequisites	None
Aim of module	This course focuses on the basic key competences that are needed to successfully write a scientific paper or a thesis. It is recommended that you take this module before you participate in a seminar. Topics include: • Scientific process and scientific writing • Bibliographic research methodology • Search strategies in bibliographic databases • Finding data for your research • How to read, understand and cite scientific literature • Reference management systems and LaTeX
Learning outcomes and qualification goals	<u>Expertise:</u> The students understand how to work scientifically and how to write a thesis.
	<u>Methodological competence:</u> The students can find relevant publications for a research question.
	<u>Personal competence:</u> • Everybody wrote a short overview of his/her research question. • Everybody installed and used exemplary tools to support the work process
Literature	• The craft of research / Wayne C. Booth; Gregory G. Colomb; Joseph M. Williams (Chicago guides to writing, editing, and publishing); 3. ed.; Chicago, Ill. ; [u.a.] : University of Chicago Press, 2008 ; XVII, 317 S. : graph. Darst. ; 22cm. • LaTeX (Wikibook): http://en.wikibooks.org/wiki/LaTeX
Methods	The students can individually work through the video recordings of the lecture and do the accompanying hands-on exercises. The live sessions will be held online as well and are mainly dedicated to clarifying any questions from the students.
Form of assessment	Eine digital unterstützte Hausarbeit
Admission requirements for assessment	Successful participation in at least 60% of all online exercises
Duration of assessment	150 minutes

Language	English
Offering	Spring semester/Fall semester
Lecturer	Lecturer from the University Library (UB)
Person in charge	Lecturer from the University Library (UB)
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, MMDS
Semester	1st/2nd/3rd semester

CS 701	**Selected Topics in Algorithmics and Cryptography**
Form of module	Seminar
Type of module	Seminar
Level	Master
ECTS	4
Workload	120 h per Semester
Prerequisites	Algorithmics (CS 550) or Cryptography II (CS 651) or Courses in Algorithms or Cryptography or Theoretical Computer Science or Complexity Security at Bsc or Msc Level, key qualification scientific research.
Aim of module	The students prepare a scientific report on a current research topic on the basis of published papers under guidance of a scientific staff member and gives a presentation. The topic will be proposed by the professor, but the students may also propose topics. Active participation in the seminar presentations of fellow students will be expected.
Learning outcomes and qualification goals	<u>Expertise:</u> The students gain a deep understanding of the research topic, are able to explain the topic in detail in a clean and transparent ways and are able to classify the significance of the topic and the results in relation to the current state of research in the corresponding research area.
	<u>Methodological competence</u> The students are able to read, to understand and to explore scientific literature relevant to the topic. They are aware of the need to avoid plagiarism.
	<u>Personal competence:</u> The student has learned how to find relevant literature for a research topic, write a well-structured and clear report about it and give a presentation. The seminar serves also as preparation for writing and presenting the master thesis.
Media	Scientific papers and books. Presentation systems like PowerPoint or beamer Latex.
Literature	Depends on the topic.
Methods	Do scientific work independently under the guidance of a research staff member and manage an active discussion on the topic in a group of peers.
Form of assessment	Presentation and discussion (15-60 minutes), Written essay/report (5-25 pages), Participation.
Admission requirements for assessment	Timely hand-in of seminar papers and presentation materials

Duration of assessment	60 minutes presentation with 15-30 minutes discussion; written report (length: 15 pages).
Language	English
Offering	Spring
Lecturer	Matthias Krause
Person in charge	Prof. Dr. Matthias Krause
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsmathematik
Semester	3rd semester

CS 704	**Master Seminar Artificial Intelligence**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Decision Support or Data Mining or Knowledge Management
Aim of module	The student prepares a scientific paper and gives a presentation on a current research topic based on published research. State-of-the-art topics are proposed by the professors. The paper and the presentation are prepared under the guidance of a professor or a research staff member. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribution of the research papers. (MK1, MK2, MK3)
	<u>Methodological competence:</u> The student is able to write a well-structured scientific paper and to present his/her results. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	<u>Personal qualification:</u> The student has learned how to write a well-structured, concise paper and give a presentation. This is part of the preparation to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books; final presentation with latex slides
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific reading independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.

Form of Assessment	We offer two types of seminars: Seminar with a focus on theory and literature: Two presentations (30 minutes overall) and a final seminar report (15-20 pages). Practical Seminar: Two presentations (30 minutes overall) and a final seminar report (12-15 pages) presenting own results. Offered in exceptional cases as group work. In such cases, the practical task is more extensive/challenging. Code has to be submitted in addition to the final report. More about content and type of the seminar can be found at https://www.uni-mannheim.de/dws/teaching/course-details/courses-for-master-candidates/
Admission requirements for assessment	-
Duration of Assessment	Both presentations must be given within a span of 5-10 weeks, the final report has to be submitted after this period
Language	English
Offering	Irregular
Lecturers	Prof. Dr. Heiner Stuckenschmidt
Person in charge	Prof. Dr. Heiner Stuckenschmidt
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	3rd semester

CS 707	**Data Analytics Seminar**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	CS Fundamentals; relevant Master Courses depending on the topic
Aim of module	The student prepares a scientific report and gives at least one presentation on a current research topic based on published research papers. The topics lie in the area of Data and Web Science and are proposed by the professor or the student. Report and presentations are prepared under the guidance of a professor or a research staff member. The student may also moderate a discussion of a presentation of a fellow student, act as a peer reviewer for the presentations or reports of other students, or experiment with a data analysis system. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contributions of the research papers.
	<u>Methodological competence:</u> The student is able to read, understand, and explore scientific literature relevant to his/her topic. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is recommended as a prerequisite for this seminar.
	<u>Personal qualification:</u> The student has learned how to find relevant literature for a research topic, write a well-structured, concise report about it and give presentations. He/she will be well prepared to write and present a Bachelor's/Master's Thesis.
Media	Scientific papers and books; software and datasets; final presentation
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of Assessment	Flash presentation (3 minutes), Final presentation (15 minutes presentation + discussion + moderation), Report (10 pages + references/appendix), Peer review, Optionally: code hand-in

Admission requirements for assessment	-
Duration of Assessment	N/A
Language	English
Offering	F SS + HWS (typically)
Lecturers	Prof. Dr. Rainer Gemulla or research staff member
Person in charge	Prof. Dr. Rainer Gemulla or research staff member
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, MSc. Mannheim Master in Data Science, Lehramt für Gymnasien
Semester	3rd semester

CS 708	**Seminar Software Engineering**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor's degree, the fundamentals
Aim of module	Student prepares a scientific paper and gives a presentation on a current software engineering research topic based on published research papers. State-of-the-art topics are proposed by the software engineering group. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> The student gains a deep understanding of the research topic. They are able to describe/summarize the topic in detail in their own words. They reflect on the topic and judges the contribution of the research papers.
	<u>Methodological competence:</u> The student is able to find the relevant literature for their topic, to write a well-structured scientific paper and to present their results. They are also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar.
	<u>Personal qualification:</u> The student has learned how to find relevant literature for a research topic, write a well-structured, concise paper about it and give a presentation.
Media	Scientific papers and books, presentation
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Scientific work performed independently under the guidance of a member of the software engineering group.
Form of Assessment	• Seminar paper (final report): 12-13 pages excluding references • Presentation (15 minutes) plus discussion (5 - 10 minutes) • Peer review: 1-5 pages • Accompanying work products (e.g., code, models, spreadsheets, documents etc.)
Duration of Assessment	Presentation (15 minutes) plus discussion (5 – 10) minutes
Language	English
Offering	Irregular
Lecturer	Colin Atkinson
Duration of module	1 semester

Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science,
Semester	1./ 2. /3. Semester

CS 709	**Seminar Text Analytics**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	IS 661 “Text Analytics” or IE 663 “Web Search and Information Retrieval” or IE 696 “Advanced Text Analytics”. Fundamental notions of linear algebra and probability theory.
Aim of module	In this seminar, students write a survey/scientific paper and provide an overview presentation of state-of-the-art research, as found within the existing literature (i.e., published research papers). Topics of interest focus around a variety of problems and tasks from the fields of Natural Language Processing and Information Retrieval. The paper and the presentation are prepared under the guidance of a professor or a research staff member.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> Students will acquire a deep understanding of the research topic. They are expected to describe in-depth and summarize the topic in detail in their own words, as well as to judge the contribution of the research papers to ongoing research.
	<u>Methodological competence:</u> Students will develop methods and skills to find relevant literature for their topic, to write a well-structured survey/scientific paper and to present their results. They will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar.
	<u>Personal qualification:</u> Students will acquire skills on how to find relevant literature for a research topic, write a well-structured, concise paper about it and present the results of their work. They are well prepared to write and present a Master’s Thesis.
Media	Scientific papers and books; presentation with PowerPoint or LaTeX.
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of Assessment	Flash presentation (3 minutes), Final presentation (15 minutes presentation + discussion + moderation), Report (10 pages + references/appendix), Peer review, Optionally: code hand-in

Admission requirements for assessment	-
Duration of Assessment	
Language	English or German
Offering	Irregular
Lecturers	Prof. Dr. Simone Paolo Ponzetto
Person in charge	Prof. Dr. Simone Paolo Ponzetto
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	3rd semester

CS 710	**Selected Topics in Data Science**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experiment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Data Mining, Web Mining, or the Semantic Web.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3)
	<u>Methodological competence:</u> Students will develop methods and skills to find relevant literature for his/her topic, to prepare methodologically sound scientific experiments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	<u>Personal qualification:</u> Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-structured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member
Form of Assessment	Seminar paper (length: 5-25 pages depending on the topic), Peer Review (1-10 pages depending on the topic), Presentation (15-60 minutes depending on the topic).

Admission requirements for assessment	-
Duration of Assessment	6-8 weeks (writing of the essay), 15-60 minutes (presentation).
Language	English or German
Offering	Irregular
Lecturers	Prof. Dr. Heiko Paulheim and Dr. Sven Hertling
Person in charge	Prof. Dr. Heiko Paulheim and Dr. Sven Hertling
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt für Gymnasien
Semester	3rd semester

CS 715	**Solving Complex Tasks using Large Language Models**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor's degree, the fundamentals
Aim of module	The seminar explores prompt engineering, fine-tuning, as well as agent-based techniques for enabling LLMs to handle complex tasks as well as using LLMs to evaluate complex outputs. The seminar features literature as well as experimental topics. The goal of the literature topics is to summarize the state of the art concerning the application and evaluation of LLMs for a specific task. The goal of the experimental topics is to verify the utility of advanced techniques by applying them to tasks beyond the tasks used in the original papers.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> Students will acquire a deep understanding of the state of the art with respect to their research topic. They learn to summarize the state of the art, judge methods along different criteria, design experiments, and present experimental results.
	<u>Methodological competence:</u> Students will develop methods and skills to find relevant literature for their topic, to prepare methodologically sound scientific experiments, and to write a well-structured scientific paper and to present their results. They will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar.
	<u>Personal qualification:</u> Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-structured, concise paper about it, and present the results of their work.
Media	Scientific papers and books
Literature	Depends on the specific topic
Teaching and Learning Methods	Perform scientific work independently under the guidance of a professor or a research staff member
Form of Assessment	Report (12 - 15 pages excluding references) Presentation (12 minutes + 8 minutes discussion)
Admission requirements for assessment	-

Duration of Assessment	6-8 weeks (writing of the seminar paper)
Language	English
Offering	Irregular
Lecturers	Prof. Dr. Christian Bizer and research staff members
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, M.Sc. Mannheim Master in Social Data Science Lehramt für Gymnasien
Semester	3rd semester

CS 716	**IT-Security**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor’s degree, the fundamentals
Aim of module	The student gives a presentation on a current research topic based on published research papers. The topics are proposed by the professor (but the student may also propose topics). The presentation is prepared under the guidance of a professor or a research staff member. The student may also moderate a discussion of a presentation of a fellow student or act as a peer reviewer for the presentations or reports of other students. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> The student gains a deep understanding of the research topic. They are able to describe/summarize the topic in detail in their own words. They reflect on the topic and judges the contributions of the research papers.
	<u>Methodological competence:</u> The student is able to read, understand, and explore scientific literature relevant to their topic. They are also aware of the need to avoid plagiarism. The key qualification Scientific Research is recommended as a prerequisite for this seminar.
	<u>Personal qualification:</u> The student has learned how to find relevant literature for a research topic, write a well-structured, concise report about it and give a presentation. They will be well prepared to write and present a Bachelor's/Master's Thesis.
Media	Scientific papers and books; final presentation with PowerPoint or similar software
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of Assessment	Grading of the oral presentation and the seminar paper.
Admission requirements for assessment	Timely hand-in of seminar paper and presentation
Duration of Assessment	45 minutes talk, 45 minutes discussion, seminar paper (8 sites, double columns)
Language	English

Offering	Irregular
Lecturers	Prof. Dr. Armknecht
Person in charge	Prof. Dr. Armknecht
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, Lehramt für Gymnasien, M.Sc. Wirtschaftsmathematik
Semester	3rd Semester

CS 717	**Master Seminar on Computer Vision**
Form of module	Seminar
Type of module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Higher Level Computer Vision, Generative Computer Vision Models, or Image Processing
Aim of module	The student prepares a scientific paper and gives a presentation on a current research topic based on published research. State-of-the-art topics are proposed by the professors. The paper and the presentation are prepared under the guidance of a professor or a research staff member. Active participation in the seminar discussions is expected.
Learning outcomes and qualification goals	<u>Expertise:</u> The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribution of the research papers. <u>Methodological competence:</u> The student is able to write a well-structured scientific paper and to present his/her results. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. <u>Personal qualification:</u> The student has learned how to write a well-structured, concise paper and give a presentation. This is part of the preparation to write and present a Master's Thesis.
Media Literature	Scientific papers and books Depending on the topic of the seminar
Methods	Do scientific reading independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of assessment	50% Presentations (one 3-5min presentation and one 25-30min presentation) 50% Seminar Report (10-20 pages, has to be submitted after three months)
Admission requirements for assessment	none
Duration of assessment	N/A
Language	English

Offering	HWS/FSS
Lecturer	Margret Keuper
Person in charge	Margret Keuper
Duration of module	1 Semester
Further modules	
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	3rd Semester

CS 720	**Uncertainty Estimation**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experiment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Data Mining, Web Mining, or the Semantic Web.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3)
	<u>Methodological competence:</u> Students will develop methods and skills to find relevant literature for his/her topic, to prepare methodologically sound scientific experiments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	<u>Personal qualification:</u> Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-structured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member
Form of Assessment	Seminar paper (length: 5-25 pages depending on the topic), Peer Review (1-10 pages depending on the topic), Presentation (15-60 minutes depending on the topic).
Admission requirements for assessment	-

Duration of Assessment	6-8 weeks (writing of the report), 15-60 minutes (presentation).
Language	English or German
Offering	Irregular
Lecturers	Tobias Weller
Person in charge	Prof. Dr. Heiko Paulheim
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt für Gymnasien
Semester	3rd semester

CS 721	**Seminar Data-Science I**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	There are no formal requirements. However, previous participation in the courses “Network Science” and “Text Analytics” are recommended.
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experiment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Data-Science, Network Science and Text Mining.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3)
	<u>Methodological competence:</u> Students will develop methods and skills to find relevant literature for his/her topic, to prepare methodologically sound scientific experiments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	<u>Personal qualification:</u> Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-structured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master’s Thesis. (MF2)
Media	slides, scientific papers, blackboard (electronic)
Literature	Depends on the topic.
Teaching and Learning Methods	Self-study of assigned material, presentation of scientific articles, joint discussion of work, collaboration with peers

Form of Assessment	• Preparation of a seminar report (12–14 pages, plus bibliography) • Presentation of the seminar paper and answering questions (40 minutes) • Participation in the presentation discussions • Reflection on a seminar report written by someone else
Admission requirements for assessment	
Duration of Assessment	
Language	English
Offering	Irregular
Lecturers	Markus Strohmaier, Marlene Lutz
Person in charge	Markus Strohmaier, Marlene Lutz
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	3rd semester

IE 704	**Seminar AI Systems Engineering**
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	None
Aim of module	The student prepares a scientific paper and gives a presentation on a current research topic based on published research. State-of-the-art topics are proposed by the supervisors. The paper and the presentation are prepared under the guidance of a research staff member. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	<u>Expertise:</u> The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribution of the research papers. (MK1, MK2, MK3)
	<u>Methodological competence:</u> The student is able to write a well-structured scientific paper and to present his/her results. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	<u>Personal qualification:</u> The student has learned how to write a well-structured, concise paper and give a presentation. This is part of the preparation to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books; final presentation with PowerPoint
Literature	Depends on the topic of the seminar.
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of Assessment	• 25% Reviews and Discussion (Review: 1-3 pages) • 25% Presentation (15 minutes presentation and 10 minutes discussion) • 25% Seminar paper submitted for review (max 20 pages in springer proceedings format)

	• 25% "Camera-ready" seminar paper (max 20 pages in springer proceedings format)
Admission requirements for assessment	-
Duration of Assessment	writing time for papers and reviews 4 to 8 weeks
Language	English
Offering	Irregular
Lecturers	Dr. Christian Bartelt
Person in charge	Dr. Christian Bartelt
Duration of module	1 Semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	3. Semester

MAS 515	**Fortgeschrittenenseminar Mathematische Optimierung** *Advanced Seminar on Mathematical Optimization*
Form der Veranstaltung	Seminar
Typ der Veranstaltung	Vertiefung
Modulniveau	Master
ECTS	4
Arbeitsaufwand	Präsenzstudium: 28 h pro Semester (2 SWS)
	Eigenstudium: • Vorbereitung des Vortrags: 62 h • Schriftliche Ausarbeitung des Vortrags: 30 h
Vorausgesetzte Kenntnisse	Analysis, Lineare Algebra, Numerik, Optimierung
Lehrinhalte	Ausgewählte fortgeschrittene Themen der Optimierung
Lern- und Kompetenzziele	Fachkompetenz: • Vertiefte Kenntnisse in einem Spezialgebiet der Numerik / Optimierung (MK1, MK2, MF2)
	Methodenkompetenz: • Fähigkeit, in einem Spezialgebiet einschlägige Fachliteratur lesen und präsentieren zu können (MF1, MO1, MO3, MO4)
	Personale Kompetenz: • Kommunikationsfähigkeit (MO3, MO4)
Medienformen	Tafelanschriebe, Präsentationen mit Beamer
Begleitende Literatur	Ausgewählte Buchkapitel, Zeitschriftenartikel der Numerik / Optimierung / Stochastischen Optimierung
Lehr- und Lernmethoden	Vorträge der teilnehmenden Studierenden
Art der Prüfungsleistung	Vortrag und schriftliche Ausarbeitung
Prüfungsvorleistung	-
Prüfungsdauer	-
Sprache	Deutsch, auf Wunsch Englisch
Angebotsturnus	unregelmäßig
Lehrende/r	Prof. Mathias Staudigl PhD
Modulverantwortlicher	Prof. Mathias Staudigl PhD
Dauer des Moduls	1 Semester
Weiterführende Module	-
Verwendbarkeit	M.Sc. Wirtschaftsmathematik, M.Sc. Mathematik, M.Sc. Mannheim Master in Data Science
Einordnung in Fachsemester	Ab dem 1. Fachsemester

G. Master Thesis

	Master Thesis
Form of module	Master Thesis
Type of module	Thesis
Level	Master
ECTS	30
Workload	Self study: 840 h per semester
Prerequisites	-
Aim of Modules	Develop a deep understanding of an advanced topic of data science
Learning outcomes and qualifications goals	Expertise: The student has a deep understanding of an advanced topic. (MK1)
	Methodological competence: The student is familiar with methods for analysing and independently solving advanced, complex problems. (MK1, MK2, MK3)
	Personal competence: The student has the capability to understand, analyse and independently find solutions to advanced, complex problems. The student has the capability to assess and understand the state-of-the-art in business informatics and adapt the latest technologies and methods to solve real world problems. The student is able to present a complex topic in written and oral form in a clear and understandable way. (MF1, MF2, MF3, MF4, MKO2, MKO3)
Media	Various
Literature	Topic dependent
Methods	Independent research work
Form of Assessment	Written thesis, 10-120 pages in length depending on the topic
Admission requirements for assessment	To be permitted to write the master thesis, the student is to obtain at least 60 ECTS
Duration of Assessment	6 months
Languages	English only
Offering	Every semester
Person in Charge	Examiners: University teachers, auxiliary professors, honorary professors and senior academic staff members of the School of Business informatics and mathematics or of the School of Social Sciences. Prof. Strohmaier. Supervisors of other faculties are possible upon application to the examination board and after examination of the content.
Duration of module	1 semester

Further modules	-
Range of Applications	MMDS
Semester	4th semester

Abbreviations

Explanation of abbreviations

Knowledge

This degree program provides students with a solid theoretical foundation as well as practical skills for data management, data analytics methods and responsible data science. The courses are divided into two groups – fundamental courses and advanced courses. After studying optional fundamental courses in computer science and empirical social sciences, in their advanced courses students can focus on the concepts and methods of computers science and advanced empirical methods and the application of these methods. In addition to the regular lecture courses, students participate in a one or two semester team project or individual project.

During their studies -

(MK1) all students develop a deep understanding of the relevant concepts, methods and problem-solving strategies used in different application domains.

(MK2) technology-oriented students learn the concepts, algorithms and strategies used to solve concrete, practical application-oriented problems in informatics.

(MK3) social sciences-oriented students develop a deep understanding of how to set up, analyse and interpret advanced empirical research questions.

As part of this education, students become familiar with a wide range of models, modelling languages, methods, and tools. Regardless of their specialization, students also learn how to collect, structure, manipulate, prepare, interpret, communicate, and use data, information, and knowledge.

Capabilities

After completing their studies, students have the ability to –

(MF1) apply a wide range of abstraction and analysis techniques.

(MF2) understand, interpret, describe, and present relevant scientific publications.

(MF3) exploit the latest scientific results.

(MF4) independently tackle problems in data management and analytics and describe their results in a structured, written form.

(MF5) continue their studies at the PhD level, if their results are of sufficient quality.

Competencies

After completing their studies, students have the competences needed to –

(MKO1) apply their knowledge and capabilities to solve specific problems in a team context.

(MKO2) use their interdisciplinary education to mediate between technical and non-technical individuals.

(MKO3) evaluate the latest changes in programming languages, systems, models and, wherever possible, exploit them to develop better solutions to data-science related problems.