



This is the consolidated version of the first amendment to the special section of the examination regulations for the 'Data Science' degree programme, which leads to a 'Master of Science' degree.

The [amendment document](#), published as Official Notice No. 1746, is legally binding.

(1) The regulation change takes effect 1 October 2026.



PROGRAMME-SPECIFIC EXAMINATION REGULATION FOR THE MASTER'S STUDY PROGRAMME 'DATA SCIENCE' AT TECHNISCHE UNIVERSITÄT BRAUNSCHWEIG

On 19 August 2026, the Faculty Council of the Carl-Friedrich-Gauß-Fakultät, and on 23 September 2026, the Dean's Office of the Carl-Friedrich-Gauß-Fakultät, acting under emergency powers, adopted the following First Amendment to the Programme-Specific Examination Regulations for the Master's programme 'Data Science' at Technische Universität Braunschweig – Announcement of 27 September 2024 (TU Gazette No. 1601) – as follows:

§ 1 Standard Period of Study

The duration of the studies, within which the study programme can be completed, is four semesters (standard duration of study).

§ 2 University Degree and Certificate

- (1) Upon passing the Master's examination, the university awards the academic degree 'Master of Science' (abbreviated to 'M. Sc.'). In addition, the university issues a certificate and a transcript in accordance with § 17(1) of the General Examination Regulations (APO) for the Bachelor's, Master's, Diploma and Magister study programmes at Technische Universität Braunschweig. A Diploma Supplement, which contains the information set out in Appendix 1, is attached to the transcript in accordance with the APO template.
- (2) In addition to the overall grade in accordance with § 17(1) of the APO, the transcript lists the grades for the individual modules with their respective credit points (ECTS). With an overall grade of 1.2 or better, the honour of 'passed with distinction' is awarded. Modules without a grade are also listed with their credit points (§ 3(9) of the APO).

§ 3 Structure of the Study Programme

- (1) The study programme is structured in the following areas:
 - Ramp-Up phase (10 CP),
 - compulsory-elective area 'Methods and Concepts of Computer Science' (25 CP),
 - compulsory-elective area 'Methods and Concepts of Mathematics' (25 CP),
 - compulsory-elective area 'Data Science in Applications' (15–20 CP),
 - compulsory elective area 'Key Qualifications and Ethics' (10–15 CP), and
 - Master's thesis including oral presentation (30 CP).
- (2) The available modules for each area are listed in appendices 2 and 3.

- (3) The Ramp-Up phase ensures a successful start in the study programme for students with various prerequisite knowledge backgrounds. The Admissions Committee determines from which subject area (Mathematics or Computer Science) the Ramp-Up phase modules must be taken. The selection of individual Ramp-Up modules is made in consultation with the mentor, in accordance with the guidelines set by the Admissions Committee. Once 50 credit points have been achieved in the course of studies, successful completion of the 'Ramp Up Course Mathematics' or 'Ramp Up Course Computer Science' module is a prerequisite for admission to further coursework and examinations.
- (4) In the area 'Data Science in Applications', students acquire subject-specific skills for the practical application of data science in various fields.
- (5) The area 'Key Qualifications and Ethics' is focused on building personal, methodological and social competencies. It includes modules covering interdisciplinary and practice-oriented topics designed to transfer interdisciplinary and practical professional qualifications and competencies.
- (6) To successfully complete the study programme, a total of 120 credit points must be achieved. Of these, in addition to the Master's thesis (30 credit points), at least 65 credit points must be achieved in graded modules. The same course cannot be credited towards different modules.

§ 4 Coursework and Examinations

- (1) The modules, qualification objectives, scope and type of assigned coursework and examinations, and the number of assigned credit points are set out in appendices 2 and 3. The exam material is derived from the qualification objectives of the modules and, supplementarily, the career requirements.
- (2) Supplementing § 9 of the General Examination Regulations for Bachelor's, Master's, Diploma and Magister study programmes at Technische Universität Braunschweig (APO), internship is a further possible form of coursework or examination. During the internship, students apply the knowledge they have acquired to data science-specific problems. They must successfully complete specific tasks, either individually or in groups. The internship is designed to help students develop the skills and abilities needed to master specialised working methods.
- (3) Homework assignment is another type of coursework. Homework helps students to prepare for, follow up on and reinforce the content covered in class. Students are expected to independently practice and consolidate the concepts and methods introduced in class using examples, and, where appropriate, to explore the subject matter in greater depth.
- (4) Colloquium and report are other types of coursework, which cover the planning, preparation and performance of the relevant tasks, as well as their critical analysis. A report contains a written presentation and critical analysis of the completed task and its solution. A colloquium is an oral assessment in the form of a discussion between the student and the examiner on the presentation and critical evaluation of the completed task and its solution.
- (5) Term papers have a separate deregistration and submission deadline. Contrary to § 11(1) of the APO, registration for the term paper examination may be retracted without giving reasons by 15 February in the respective winter semester and by 15 August in the respective summer semester. In addition to § 9c of the APO, the submission deadline for term papers is 15 March of the respective winter semester and 15 September of the respective summer semester. A student may only register for a term paper if they have previously been assigned a topic for that paper. Registration for the term paper examination counts as the student's confirmation that they have been assigned a topic for a term paper.

- (6) Supplementing § 9i of the APO, portfolio examination is subject to a separate registration and deregistration deadline. Registration for and deregistration from a portfolio examination is only possible within four weeks after the start of the lecture period of the respective semester.
- (7) Every student in the Data Science Master's programme is obligated to complete a seminar, which concludes with an examination. The topic of the seminar must be in the field of data science. Students may choose a seminar from either the 'Data Science Seminar – Mathematics Section' or the 'Data Science Seminar – Computer Science Section' modules. Other seminars cannot be credited towards the study programme. A separate registration and deregistration deadline applies for seminars. Registration in the examination for seminars must be completed by the day of the kick-off event of the respective seminar. Deregistration from seminars is only possible within two weeks after the start of the lecture period of the respective semester.
- (8) The topic of the seminar can be set by faculty members of the Departments of Computer Science and Mathematics, as well as by full-time private lecturers in those departments. With the approval of the Examination Board, the topic can also be assigned by retired professors from the Departments of Computer Science and Mathematics and by other persons authorised to conduct examinations in accordance with § 5(1) of the APO.
- (9) The optional project work comprises 15 credit points and is part of the compulsory-elective area 'Data Science in Applications'. The completion period for project works, from the assignment of topic until the submission of project work, is three months. Withdrawal is permitted up to two weeks after the topic has been assigned. The assignment of the project topic must be recorded in the student's file. An extension of the completion period may be granted upon the student's request if the reasons for this request are beyond the student's control. The extension must be recorded in the student's file. If the completion period exceeds the approved period, the project will be graded as 'non-sufficient'.
- (10) The topic of the project work can be assigned by faculty members, as well as by full-time private lecturers in the Departments of Computer Science and Mathematics, and by those responsible for modules in the compulsory-elective area 'Data Science in Applications'. With the approval of the Examination Board, the topic can also be assigned by retired professors from the Departments of Computer Science and Mathematics.
- (11) A module that is not listed in the appendices or in a list of further possible modules approved by the Data Science Examination Board may be approved by the Data Science Examination Board upon request of a student, provided that this module meaningfully complements the student's study plan.
- (12) The regulations of § 13(5) of the APO apply to supplementary oral exams. The following supplementary or alternative regulations apply to the Data Science Master's programme: Within one month after the announcement of the grades for the written examination, the examinee must arrange a date for the supplementary oral exam with the examiner and notify the Examination Board or the body appointed by it. If the Examination Board does not receive the exam date from the examinee within the one-month deadline, the Examination Board will assign a date for the supplementary oral exam to the examinee. The date of the supplementary oral exam must be set by the examiner in such a way that it takes place by 15 November at the latest for the previous summer semester and by 15 May for the previous winter semester. If the student fails to attend the supplementary oral exam and there are valid reasons for this (such as unforeseen obstacles or emergencies) the Data Science Examination Board may, in individual cases, extend the deadline in accordance with § 11(3) of the APO. These reasons must be presented to the Examination Board in writing without delay.
- (13) If the student is unable to attend the supplementary oral exam due to illness, a doctor's note in accordance with § 11(3) of the APO, a certificate from a specialist doctor, a psychologist or a psychotherapist must be submitted within three workdays; this certificate must be sufficiently detailed to enable the Examination Board to determine the cause, severity, type and, when

applicable, the duration of the impairment. The same regulations apply here as for withdrawal, in accordance with Section 16.

- (14) Supplementing § 5(4) of the APO, in addition to the first and second examiners, a notetaker may also be present at supplementary oral exams to document the course of the examination. The same applies, supplementarily, to final oral repeated examinations in accordance with § 9b, sentence 5 of the APO. The notetaker themselves must have at least the qualification that is being assessed in the examination or an equivalent qualification. The notetaker cannot influence the final grading. The examiners must ensure that the notetaker cannot influence the grading process. The notetaker is appointed by the first examiner.
- (15) Failed examinations must, as a general rule, be retaken during the course of studies. In accordance with § 13(4) of the APO, a student may apply to the Data Science Examination Board to be exempted from retaking the failed exam for a maximum of three different examinations, provided that alternative examination options are available. Contrary to § 13(4) of the APO, dropping a module is possible until the end of the study programme. Compulsory modules cannot be dropped.
- (16) If you are unable to attend an exam due to illness on the day of the examination, a medical doctor's note is required. This must be submitted to the Examinations Office within three workdays (if sent by post, the date of the postmark will be taken as the date of submission). The day of the examination is counted as the first workday. A Saturday also counts as a workday. If the final day of the submission period for the doctor's note falls on a Saturday, Sunday or public holiday, the deadline for submitting the doctor's note is extended by that day accordingly, and it may be submitted on the following workday. Otherwise, the examination will be marked as 'absent' (grade 5.0). If a student is unable to attend the same examination for the third time due to illness, then, in accordance with § 11(3) of the APO, a certificate from a specialist doctor, a psychologist or a psychotherapist must be submitted in place of a doctor's note; this certificate must be sufficiently detailed to enable the Examination Board to determine the cause, severity, type and, where applicable, the duration of the impairment. The same submission deadline of three workdays applies here, in accordance with sentences 2 to 6.
- (17) In accordance with § 18 of the APO, credit points may be earned in the form of additional coursework beyond the scope specified for the Data Science Master's programme until the end of the semester in which the coursework and/or examinations required to graduate from the Master's programme have been fully completed. However, a request to take additional coursework can only be submitted once at least 30 credit points have been earned from modules completed for and as part of the Data Science Master's programme.
- (18) Partial recognition of examinations is not permitted. Requests for recognition must be submitted within the first semester of study; if the credit was obtained at a later date, the request must be submitted by the end of the following semester. If parts of a module are recognised by the Data Science Examination Board, the module in question must be completed by the end of the study programme.
- (19) Students must register for all assessed coursework (examinations) within the registration period in a given semester, with the Data Science Examination Board, either in writing or electronically via the portal provided for this purpose.
- (20) In order to ensure their identity, students are required to use the email address provided by Technische Universität Braunschweig for all electronic communication relating to their studies.
- (21) Supplementing § 12(2) of the APO, examinations may also be assessed as 'pass'/'fail' (without a grade).

§ 5 Master's Thesis

- (1) The Master's thesis is the final assignment in accordance with § 14 of the APO. The following additional regulations also apply.
- (2) To register for the Master's thesis, students must have successfully completed at least 75 credit points' worth of modules from the Data Science Master's programme.
- (3) The topic of the Master's thesis must be in the field of data science and can be assigned by faculty members of the Departments of Computer Science and Mathematics in the Carl-Friedrich-Gauß-Fakultät, as well as by full-time lecturers in both departments. Upon application and with the approval of the Examination Board, the topic can also be assigned by faculty members from the Application Area or retired professors from the Departments of Computer Science and Mathematics. In the case of the second sentence, the second examiner must be a full-time professor from the Department of Computer Science or the Department of Mathematics. A corresponding application must be submitted to the Examination Board at least one week before the written registration for the Master's thesis.
- (4) The following can be appointed as second examiners: faculty members from the Departments of Computer Science and Mathematics at the Carl-Friedrich-Gauß Faculty, and full-time private lecturers from both departments.

At the request of the student and with the approval of the Examination Board, the following may also be appointed as second examiners:

- a) retired professors from the Departments of Computer Science and Mathematics at the TU Braunschweig,
 - b) members of the academic staff group and full-time private lecturers from other departments or faculties at the TU Braunschweig,
 - c) faculty members and full-time private lecturers from other higher education institutions or universities, provided they are authorised at their institution to supervise and examine Master's theses.
- (5) The completion period, from the assignment of the topic until the submission of the Master's thesis, is six months. The topic may only be withdrawn once, and only within two months after its assignment. Upon a justified request to the Examination Board and where there are valid reasons, the completion period may be extended by up to two months.
 - (6) In the case of illness whilst working on the Master's thesis, a doctor's note must be submitted. The doctor's note must be received by the Examinations Office on the third working day after the illness was identified (if sent by post, the date of the postmark applies). The day on which the illness was identified counts as the first working day. A Saturday also counts as a working day. If the final day of the submission period for the certificate falls on a Saturday, Sunday or public holiday, the deadline is extended by that day accordingly, and the medical certificate may be submitted on the following working day. If two medical certificates have already been submitted whilst writing the Master's thesis, the third and any further doctor's notes must, in accordance with § 11 (3) of the APO, be a certificate from a specialist doctor, a psychologist or a psychotherapist; which must be sufficiently detailed to allow the Examination Board to determine the cause, severity, type and, where applicable, the duration of the impairment. The same submission deadline of three working days applies here, in accordance with sentences 2 to 5.
 - (7) Before the thesis is evaluated, the student holds a 30-minute presentation in which they showcase their work. The presentation can account for up to 3 out of 30 credit points in the assessment of the thesis, provided that it meaningfully contributes to achieving the qualification objectives for the

chosen topic. Upon assigning the topic, the examiner will specify whether, and to what extent, the presentation will be taken into account in the final grade.

§ 6 Calculation of the final grade

- (1) In accordance with § 16(2) of the APO, the final grade for the Master's examination is calculated as the average of the grades weighted by credit points for the modules, including the Master's thesis. If, in accordance with § 16(2) of the APO, the module grades are included in the final grade with a weighting different from that of the module, this is specified for the individual modules in Appendix 3.
- (2) Completed coursework can be with or without a grade. The grade for any such coursework is not included on the transcript and is not taken into account when calculating the final grade.
- (3) If more modules are completed than specified in the examination regulations, and if the exams were not registered as supplementary exams, the module grades are included in the calculation of the final grade in chronological order according to the module completion date, in accordance with § 16(2) APO, until the required number of credit points is reached or exceeded. Additional modules will be disregarded. The disregarded modules will not be listed on the transcript and cannot be converted into supplementary examinations.
- (4) The request to have supplementary examinations included on the degree certificate must be submitted no later than four weeks after taking the final examination required for the study programme. If supplementary examinations are to be taken after completion of the study programme, the request for these examinations to be included on the degree certificate must be submitted within four weeks after the last supplementary examination has been taken. Coursework and/or examinations submitted as supplementary examinations cannot subsequently be converted into coursework and/or examinations relevant to the study programme.

§ 7 Mentoring and Counselling Sessions

- (1) Each student is assigned a mentor from the faculty members of the departments of Computer Science or Mathematics by the Data Science Examination Board at the start of their study programme. A change of mentor is possible at any time at the request of either party.
- (2) The mentor's role is to work together with the students to set individual areas of focus for their studies (see § 3, sections 4 and 5). At the students' request, regular meetings are held with the mentor to discuss the academic progress.
- (3) Students who have not earned at least 30 credit points by the end of the second semester are required to attend a counselling session. Admission to further coursework and examinations is conditional upon proof of attendance at the counselling session. This proof must be submitted by the first day of the examination registration period for the third semester. If the proof is not provided in the third semester, admission to examinations and further study modules in subsequent semesters shall also be withheld until the proof has been provided by the deadline. The deadline for submitting the proof for subsequent semesters is also the first day of the examination registration period respectively.

§ 8 Examination Board

Supplementing § 4(5) of the APO, the Chair can appoint a notetaker for the Examination Board meetings. Provided that the notetaker is a member of staff of the Examinations Office, they may also

provide information on the facts of the case or the legal position. However, they are not permitted to participate in any way in the decision-making process.

§ 9 Commencement and Transitional Provisions

- (1) These examination regulations are effective from 01.10.2026. At the same time, the passages of the previous Special Section of the Examination Regulations (Announcement of 27 September 2024, TU Gazette No. 1601) that have been replaced or deleted by these regulations cease to apply.
- (2) For students studying under the Special Examination Regulations of 27 September 2024 (TU Gazette No. 1601), § 4 to § 8 of these First Amending Regulations also apply.
- (3) The regulations of the revised Examination Regulation – published in the notice dated 27 September 2024 (TU Gazette No. 1601) – continue to apply in their updated and supplemented form. The amendments listed below apply to students who, when these First Amending Regulations enter into force, are subject to the Examination Regulations for the Master's programme in 'Data Science' dated 27 September 2021 (TU Gazette No. 1373), as last amended on 22 September 2023 (TU Gazette No. 1517):
 - a) § 4 to § 7 of this Examination Regulation apply. § 4 to § 7 of the Examination Regulation cease to apply.
 - b) The current regulations regarding the Examination Board (see § 8) apply.
 - c) The current version of the Ramp Up Course in Mathematics (V2) is replaced by the new version, the Ramp Up Course in Mathematics (V3).
 - d) Students who, on 1 October 2026, are in their sixth or higher semester and have successfully completed the module 'Deep Learning in Remote Sensing' (BAU-STD5-59 – 6 ECTS) will have this recognized within the area 'Data Science in Applications'. The modules 'Deep Learning in Remote Sensing' (BAU-STD5-86 – 5 ECTS) and 'Machine Learning' (BAU-STD5-87 – 5 ECTS) can then no longer be taken or credited.
 - e) Upon request, students can be assessed in accordance with the new regulations and appendices – but now in accordance with the First Amendment regulations.
 - f) Appendix 2 of these amending regulations applies.
- (4) Students who, at the time these regulations come into effect, are subject to either of the following Examination Regulations for the Master's Degree Programme in 'Data Science':
 - the Regulations dated 27 September 2021 (TU Gazette No. 1373), as last amended on 22 September 2023 (TU Gazette No. 1517),
 - or
 - the Regulations dated 27 September 2024 (TU Official Gazette No. 1601),

may continue to be assessed in accordance with these regulations until 30 September 2028. Students may also, upon request, be assessed in accordance with the new regulations and appendices. However, a switch is not permitted if modules have been started but not completed. It is not possible to subsequently switch back to the previous regulations. From 1 October 2028 at the latest, all students will be examined in accordance with the amended regulations in force at that time (currently the First Amendment). Coursework and examination results already achieved for equivalent modules will generally be recognised in the event of a change to the examination regulations.

Appendix 1 Diploma Supplement: Programme-Specific Components

2. ANGABEN ZUR QUALIFIKATION 2.1 Bezeichnung der Qualifikation und (wenn vorhanden) verliehener Grad (in Originalsprache) Master of Science (M. Sc.) 2.2 Hauptstudienfach oder –fächer für die Qualifikation Data Science 2.3 Name und Status (Typ/Trägerschaft) der Einrichtung, die die Qualifikation verliehen hat (in Originalsprache) Technische Universität Carolo-Wilhelmina zu Braunschweig Carl-Friedrich-Gauß-Fakultät Universität/Staatliche Einrichtung 2.4 Name und Status (Typ/Trägerschaft) der Einrichtung (falls nicht mit 2.3 identisch), die den Studiengang durchgeführt hat (in Originalsprache) Technische Universität Carolo-Wilhelmina zu Braunschweig Carl-Friedrich-Gauß-Fakultät Universität/Staatliche Einrichtung 2.5 Im Unterricht / in der Prüfung verwendete Sprache(n) Englisch, in einigen Fällen Deutsch 3. ANGABEN ZU EBENE UND ZEITDAUER DER QUALIFIKATION 3.1 Ebene der Qualifikation Master-Studium (Graduate/Second Degree) 3.2 Offizielle Dauer des Studiums (Regelstudienzeit) in Leistungspunkten und/oder Jahren 2 Jahre Vollzeitstudium (inkl. Schriftlicher Abschlussarbeit), 120 ECTS Leistungspunkte 3.3 Zugangsvoraussetzung(en) Qualifizierter Bachelor-Abschluss (oder gleichwertiger Abschluss) Bachelor in Informatik oder Mathematik oder vergleichbarer Abschluss im selben oder thematisch ähnlichen Gebiet 4. ANGABEN ZUM INHALT DES STUDIUMS UND ZU DEN ERZIELTEN ERGEBNISSEN 4.1 Studienform Vollzeitstudium 4.2 Lernergebnisse des Studiengangs Gegenstand des Masterstudiums sind fachliche Vertiefungen und fortgeschrittene Kenntnisse in allen für Data Science relevanten Bereichen. Die Absolventen erlangen vertiefte Kenntnisse über mathematische und informatische Methoden der Data Science. Sie erlangen ergänzend Einblicke in Anwendungsgebiete für Techniken der Data Science und in die damit verbundene aktuelle Forschung. In einem der ausgewählten Vertiefungsbereiche aus mathematischen oder informatischen Grundlagen oder aus einem Anwendungsbereich muss eine Master-Abschlussarbeit im Umfang eines Semesters selbständig angefertigt werden. Die Absolventen • können Methoden und Konzepte der Datenakquisition, Datenintegration und Datenhaltung analysieren und effektiv nutzen. • können Analysemethoden und Algorithmen für verschiedene Fragestellungen kompetent auswählen, kombinieren, an ein ausgewähltes Anwendungsfeld anpassen und	2. INFORMATION IDENTIFYING THE QUALIFICATION 2.1 Name of qualification and (if applicable) title conferred (in original language) Master of Science (M. Sc.) 2.2 Main Field(s) of study for qualification Data Science 2.3 Name and status of awarding institution (in original language) Technische Universität Carolo-Wilhelmina zu Braunschweig Carl-Friedrich-Gauß-Fakultät University/State institution 2.4 Name and status of institution (if different from 2.3) administering studies (in original language) Technische Universität Carolo-Wilhelmina zu Braunschweig Carl-Friedrich-Gauß-Fakultät University/State institution 2.5 Language(s) of instruction/examination English, in some cases German 3. INFORMATION ON THE LEVEL AND DURATION OF THE QUALIFICATION 3.1 Level of the qualification Graduate/Second Degree, by research with thesis 3.2 Official duration of programme in credits and/or years 2 years full-time study (incl. thesis), 120 ECTS credits 3.3 Access requirement(s) Bachelor Degree in Computer Science or Mathematics or equivalent degree (three or four years) in the same or closely related field 4. INFORMATION ON THE PROGRAMME COMPLETED AND THE RESULTS OBTAINED 4.1 Mode of study Full-time 4.2 Programme learning outcomes Subject of the Master programme is the deepening of knowledge in the data science field. Students get deepened knowledge about mathematical and computer science methods of data science. They get additional insights into application areas for techniques of data science and the connected current research. The students have to complete a master thesis of one semester in the mathematical, computer science or application fields of the data science programme. The graduates • can analyze methods and concepts of data acquisition, data integration and data storage and use them effectively. • can competently select analysis methods and algorithms for various problems, combine them, adapt them to a selected field of application and develop them further. • are able to correctly assess the informative value of data instances and the analysis methods used
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weiterentwickeln. • können die Aussagekraft von Dateninstanzen und den verwendeten Analysemethoden korrekt und dem Analysezzweck entsprechend einschätzen. • können in einem ausgewählten Anwendungsfeld datengetriebene Lösungen entwickeln und Analysemethoden zielführend einsetzen. • können Datenprojekte in Unternehmen leiten und Entscheidungsprozesse in der Datenhaltung und -analyse effektiv managen. • tragen zur Lösung von Aufgabenstellungen im Bereich Data Science sowohl aus erklärungsorientierter als auch aus gestaltungsorientierter Sicht bei. • kennen, auch zur eigenständigen Weiterentwicklung, relevante Informationsquellen sowie die einschlägigen Regelwerke und den Zugang zu diesen Materialien. • können analytisch denken, komplexe Zusammenhänge erkennen, vorhandene und neue Problemlösungen einschätzen und mit Hilfe einer Anwendung integraler Kenntnisse aus dem Bereich Data Science eigene Lösungen entwickeln. • können erfolgreich in einer Gruppe arbeiten und effizient mit verschiedenen Zielgruppen kommunizieren. • können sich in aktuelle Forschungsergebnisse des Fachs einarbeiten und diese weiterentwickeln. • sind damit befähigt eine wissenschaftliche Tätigkeit mit dem Ziel einer Promotion auszuüben.	and in accordance with the purpose of the analysis. • can develop data-driven solutions in a selected field of application and use analysis methods in a targeted manner. • can lead data projects in companies and effectively manage decision-making processes in data storage and analysis. • contribute to solving tasks in the field of data science from both an explanatory and a design-oriented perspective. • know, also for independent further development, relevant sources of information as well as the relevant regulations and access to these materials. • can think analytically, recognize complex relationships, assess existing and new solutions to problems and develop their own solutions with the help of integral knowledge from the field of data science. • can work successfully in a group and communicate efficiently with different stakeholders. • can familiarize themselves with current research results in the subject and develop them further. • are thus able to carry out a scientific activity with the aim of a doctorate.
4.3 Einzelheiten zum Studiengang, individuell erworbene Leistungspunkte und erzielte Noten Einzelheiten zu den belegten Kursen und erzielten Noten sowie den Gegenständen der mündlichen und schriftlichen Prüfungen sind im „Prüfungszeugnis“ enthalten. Siehe auch Thema und Bewertung der Masterarbeit.	4.3 Programme details, individual credits gained and grades/ marks obtained See (ECTS) Transcript for list of courses and grades; and “Prüfungszeugnis” (Final Examination Certificate) for subjects assessed in final examinations (written and oral); and topic of thesis, including grading.
4.4 Notensystem und (wenn vorhanden) Notenspiegel Allgemeines Notenschema (Abschnitt 8.6): 1,0 bis 1,5 = „sehr gut“ 1,6 bis 2,5 = „gut“ 2,6 bis 3,5 = „befriedigend“ 3,6 bis 4,0 = „ausreichend“ Schlechter als 4,0 = „nicht bestanden“ 1,0 ist die beste Note. Zum Bestehen der Prüfung ist mindestens die Note 4,0 erforderlich. Ist die Gesamtnote 1,2 oder besser wird das Prädikat „mit Auszeichnung bestanden“ vergeben. ECTS-Note: Nach dem European Credit Transfer System (ECTS) ermittelte Note auf der Grundlage der Ergebnisse der Absolvent*innen der zwei vergangenen Jahre: A (beste 10 %), B (nächste 25 %), C (nächste 30 %), D (nächste 25 %), E (nächste 10 %) 6. WEITERE ANGABEN	4.4 Grading system and (if available) grade distribution table General grading scheme (Sec. 8.6): 1.0 to 1.5 = “excellent” 1.6 to 2.5 = “good” 2.6 to 3.5 = “satisfactory” 3.6 to 4.0 = “sufficient” Inferior to 4.0 = “Non-sufficient” 1.0 is the highest grade, the minimum passing grade is 4.0. In case the overall grade is 1.2 or better the degree is granted “with honors”. In the European Credit Transfer System (ECTS) the ECTS grade represents the percentage of successful students normally achieving the grade within the last two years: A (best 10 %), B (next 25 %), C (next 30 %), D (next 25 %), E (next 10 %) 6. ADDITIONAL INFORMATION

In case of ambiguity, only the German version of this document is legally binding.

6.2 Weitere Informationsquellen

www.tu-braunschweig.de
www.tu-braunschweig.de/fk1
www.tu-braunschweig.de/data-science

6.2 Further information sources

www.tu-braunschweig.de
www.tu-braunschweig.de/fk1
www.tu-braunschweig.de/en/data-science

Appendix 2 Area ‘Key Qualifications and Ethics’

In the area ‘Key Qualifications and Ethics’, the modules ‘Ethics and Epistemology’ and ‘Scientific and Method-Oriented Working’ are compulsory.

Further credit points may be earned in courses designed to develop key qualifications. These must be selected from, amongst other sources, the overall programme (pool) of interdisciplinary courses offered by the Technische Universität Braunschweig and are completed with ungraded coursework. Courses from modules in Computer Science and Mathematics or from the application area, as well as courses offered by the Sports Centre, cannot be counted towards this requirement.

The Data Science Examination Board can exclude courses from the pool programme or approve additional courses. For the recognition of other courses or modules in the ‘key qualifications’ area, a written request must be submitted to the Examination Board.

Courses offered by the Language Centre can be credited for a maximum of 5 credit points.

Language courses may be credited from the following level onwards:

- Foreign languages from level B1 upwards
- German language courses from level B1 upwards may be credited

Language courses in the student’s native language or in the official languages of their home country, and English courses, are not recognized.

An active proof of performance is required for the selected courses/modules (e.g. written examination, term paper, presentation, minutes). A certificate of attendance is not sufficient. The type of academic work required depends on the module or course.

Appendix 3 Module Descriptions

Description of the Modules (see Module Guide)



Modules of the degree program

PO 3

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Ramp Up Phase

Title	Ramp up Course Mathematics
Number	1294580
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 ungraded examination (Prüfungsleistung): 1 written exam (1 written exam 120 minutes + 6 shorter optional sub-exams, each worth two points for the written exam) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	
Objective qualification	
The students - know understand the underlying concepts of mathematics that are necessary for data science - understand the concepts of analysis, algebra, optimization, discrete mathematics, stochastics and numerics and are able apply them in the context of data science	



Title	Ramp up Course Computer Science
Number	4298040
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Ungraded examination (Prüfungsleistung): 1 written exam (120 min.), oral exam (30 minutes) or Take-Home-Exam
Course achievement	
Objective qualification	
After successful completion of this module, students have a basic understanding of the underlying concepts of computer science that are necessary for data science. They are able to - design and develop software systems for data analysis - understand and implement distributed analysis processes - apply and operate modern database systems - evaluate and protect the security and privacy of data	

Further, students have a general overview of the methods of data science and the application areas. They know the general principles and processes of data science projects.

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Methods and Concepts of Computer Science

Title	Pattern Recognition
Number	2424690
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Oral exam 30 min. or written exam 90 min.
Course achievement	
Objective qualification	
Upon completion of this module, students gain fundamental knowledge about methods and algorithms for classification of data. They are capable to select the appropriate means for real-world problems, to design a solution and to evaluate it.	



Title	Deep Learning Lab
Number	2424750
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	



Title	Knowledge based systems and deductive database systems
Number	4214620
ECTS	5,0
Compulsory requirements	
Compulsory	

attendance	
Expected performance/ Type of examination	1 written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.
Course achievement	50% of the exercises must be passed
Objective qualification	
On completion of this module, students are aware of the challenges and problems which arise from reasoning processes over large knowledge bases. This covers technical aspects (algorithms, implementations, etc.) and also methodological aspects (e.g. uncertainty, etc.). Furthermore, the students will be able to discuss the strengths and weaknesses of different approaches to reasoning and will be able to competently propose solution strategies to practical problem scenarios.	

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Title	Data Warehousing and Data Mining Techniques
Number	4214680
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 written exam (90 minutes), oral exam (30 minutes) or Take-Home-Exam
Course achievement	50% of the exercises must be passed
Objective qualification	
Data warehousing and mining the data within warehouses represent an important basis for corporate decision support. Students understand possible data warehouse architectures and their essential processes and know the details of the major data mining algorithms used, to be able to correctly and meaningfully underpin decisions with data. They are enabled to critically analyze and evaluate the respective application of various algorithms.	

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Title	Information retrieval and web search engines
Number	4214690
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 written exam (90 minutes) or oral exam (30 minutes) or Take-at-Home-Exam

Course achievement	50% of the exercises must be passed
Objective qualification	
Information retrieval techniques play a central role not only in Web search engines, but in all kinds of document-centric applications. Students need to understand different techniques, their typical application areas and limitations, as well as their advantages and disadvantages. They are enabled to choose the right techniques for the respective practical problem and to critically reflect their use in the respective application context.	

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Title	Introduction to Machine Learning
Number	4215370
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.
Course achievement	
Objective qualification	
With successful completion of the module, the students possess the following knowledge and capabilities. They are able to - understand and correctly apply basic concepts of machine learning - analyse and formalize a machine learning problem - distinguish between typical machine learning methods - select a suitable method for a learning problem - compare and judge machine learning methods wrt their capacity - implement machine learning methods and apply them practically - apply and parametrise respective tools - judge strength and weaknesses of machine learning in applications - recognize ethical issues in the application of machine learning	

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Title	Visualization Techniques
Number	4216340
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	

Course achievement	1 Presentation
Objective qualification	
This course offers an overview of computer graphics visualization. It conveys the psychological foundations of visual information perception and provides insight into their algorithmic implementation as basis for various visualization techniques. Graduates of this course will be familiar with relevant aspects of visual perception and cognition theory as well as algorithmic concepts of visualization.	

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Title	Image Aspects
Number	4216350
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	1 Presentation
Objective qualification	
This course offers insight into the formation, perception, and cognition of images. The natural phenomenon of images will be considered from the viewpoint of physics, information theory, neuroscience, and arts history. Graduates of this course will be familiar with relationships between optics, digital image processing, image statistics, visual perception, cognitive science and visual arts	

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Title	Python Lab
Number	4217850
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	1 Team-based development and documentation of a data science software tool
Objective qualification	
After successful completion of this module, students will have the competence to apply Python for designing and implementing small to medium software projects and analytic workflows with a focus on statistics and machine	

learning. During an interactive learning phase during which the students will be able to apply common packages such as scikit-learn, and they will be able to synthesize analysis workflows for diverse data science questions. These workflows will be presented and discussed in a mini-conference among the students. After the mini-conference, students will form small teams to develop data science software tools which will be presented during the closing event. They will gain the competence to critically evaluate machine learning workflows.



Title	Computational Geometry
Number	4227250
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded work: written exam (120 minutes) or oral exam (30 minutes). The form of the examination depends on the number of participants and will be announced at the beginning of the lecture.
Course achievement	nongraded work: 50% of the exercises must be passed
Objective qualification	
Students who complete the module are familiar with basic modeling of geometric algorithms. They are able to classify the algorithmic difficulty of geometric problems and formulate appropriate objectives. They are proficient in various solution techniques and can also develop algorithmic methods for problems not previously considered. They have an overview of the practical relevance of problems and problem solutions.	



Title	Approximation Algorithms
Number	4227270
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded work: written exam (120 minutes) or oral exam (30 minutes) minutes) or Take-Home-Exam. The form of the examination depends on the number of participants and will be announced at the beginning of the lecture.
Course achievement	non-graded work: 50% of the exercises must be passed
Objective qualification	
Participants know the necessity and role of approximation algorithms. They can master the most important techniques for analysis and complexity of approximation algorithms for designing, including the validity of upper and lower bounds.	



Title	Graphs, Geometry, and Algorithms
Number	4227300
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 written exam, 90 minutes, or 1 oral exam, 30 minutes or Take-Home-Exam
Course achievement	50% of the homework must have been successfully completed
Objective qualification	
Graduates of this module know different geometric representations of graphs. They can gauge the algorithmic complexity of computing such representations or deciding whether such a representation exists. They understand how such representations may help to solve otherwise difficult problems and are capable of developing algorithmic methods for new problems. In many contexts, it is useful to visualize data organized in graphs. For this purpose, approaches from algorithms, graph theory and algorithmic geometry join forces. This class will be held in English. Students are encouraged (but not required) to use English in exercises and exams as well.	



Title	Fundamentals of High-Performance Computing for CFD simulations
Number	2518000010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	
Objective qualification	
Attending the course, the students will be able to: • Understand and use the fundamentals of the Linux-operating system and basic Unix tools • Automate HPC workflows using Shell-scripts • Write, compile and debug programs in C++ • Automate the steps of compiling, testing and executing • To structure the development process of program code using software	



Title	Software Product Lines
Number	4220000020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 graded work: Written exam+ (90 minutes) or oral exam+ (20 minutes)
Course achievement	1 non-graded work: Solve exercises relevant to the lecture
Objective qualification	
Students are able to • identify the limitations of traditional programming techniques regarding the development of variable software. • describe modeling, analysis and configuration of variability in software product lines. • apply different implementation techniques for the development of software product lines. • evaluate the suitability of presented programming techniques for different development scenarios. • explain quality assurance techniques for software product lines and the associated challenges.	



Title	Seminar Data Science - Section Computer Science
Number	4299000070
ECTS	5,0
Compulsory requirements	
Compulsory attendance	Mandatory attendance at seminars
Expected performance/ Type of examination	1 Course Assessment: Presentation, including mandatory attendance (with absences). The grade is determined based on active participation in the seminar, the quality of the presentation, and any accompanying paper; the accompanying paper may also be replaced by a second presentation.
Course achievement	
Module grade composition	The grade is determined by the active participation in the seminar and the quality of the presentation and the accompanying paper.
Objective qualification	
Students will learn how to conduct independent research on a topic, prepare a presentation on it and deliver it. They will also become aware of the impact their presentation has on their peers. They will also acquire important key competencies, such as practising and improving their presentation and rhetorical skills, and	

engaging in substantive — and sometimes controversial — discussions with other participants on the topics presented.



Title	Machine Learning for Data Science
Number	4229000050
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination: written exam, 90 minutes or oral exam, 30 minutes or take-home exam
Course achievement	1 academic achievement: 50% of the exercises must be passed
Objective qualification	
After successfully completing this module, students should be able to - understand and correctly apply basic concepts of machine learning algorithm design, - master elementary tools for analyzing the performance of machine learning approaches, - identify the most suited ML approaches for a particular application.	



Title	Constraint Solving
Number	4220000040
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 Examination: Exam or exam+ (90 minutes), oral exam or oral exam+ (20 minutes) or take-home exam
Course achievement	1 study achievement: Passing practical tasks
Objective qualification	
The students learn to recognize application scenarios of learned techniques in practice. The students learn to evaluate the suitability of different approaches for a given problem setting and select promising solution. The students should acquire a basic understanding of the underlying techniques.	



Title	AI Engineering
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Number	2424000050
ECTS	5,0
Compulsory requirements	Basic knowledge (in theory and practice) in machine learning is required, e.g. from-Mustererkennung / Pattern Recognition (2424102) und im Computerlabor Mustererkennung (2424133).
Compulsory attendance	
Expected performance/ Type of examination	Written exam (120 min) or oral exam (30 min)
Course achievement	Lab work
Objective qualification	
Students are able to explain the structure, functionality, and application of foundation models (large, generally pre-trained AI models) and describe their core components such as tokenization, embeddings, transformer architectures, and training procedures. They can apply methods such as prompt engineering, retrieval-augmented generation, finetuning, and agent systems to adapt AI models to specific tasks. Furthermore, they are able to analyze technical concepts, select appropriate tools, and design and evaluate AI applications while considering legal and ethical frameworks. In the accompanying lab sessions, students implement and experiment with the presented methods in practice, thereby deepening their understanding through hands-on experience.	

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Title	Distributed Data Management
Number	4214580
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes) or Take-Home-Exam.
Course achievement	1 Coursework: 50% of the exercises must be passed
Objective qualification	
After completing this module, students will have acquired fundamental knowledge in the areas of distributed database systems and peer-to-peer data management.	

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Title	Advanced Artificial Intelligence 1
Number	4229000020
ECTS	5,0
Compulsory	

requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination: written exam, 90 minutes or oral exam, 30 minutes or take-home exam
Course achievement	1 academic achievement: 50% of the exercises must be passed
Objective qualification	
After successfully completing this module, students have acquired expertise in some of the current advanced topics in AI.	

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Methods and Concepts of Mathematics

Title	Algorithms and Complexity for Quantum Computing
Number	1294480
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - master the fundamentals to understand the model of a quantum computer - know the algorithmic applications of this model - know and understand the quantum computer model in light of the theory complexity	



Title	Computational Algebraic Geometry
Number	1294470
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications.

	The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - understand the basic concepts of computer algebra techniques in theory and practice, such as the Euclidean algorithm and Gröbner bases, their calculation and application - understand number theoretic and algebraic techniques and are able to apply and analyze them - are able to calculate factorizations and to apply and analyze methods to solve systems of nonlinear equations and for working with algebraic objects	

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Title	Discrete Optimization
Number	1294460
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.

Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand combinatorial and discrete optimization problems - understand the notions and results of theory of complexity - understand the important theorems, proofs and procedures of discrete and combinatorial optimization and are able to apply and analyze them - know general algorithmic principles and problem structures - are able to design, apply and analyze algorithms for applications, in particular, for NP-hard problems	

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Title	Dynamic Optimization
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Number	1294450
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand the problems of optimal control, parameter estimation, optimal experimental design and model discrimination - know and understand the different fundamental approaches in the field of optimal control are are able to apply and analyze them - are able to analyze, interpret, refine and enhance the methods, especially to increase the efficiency of numerical algorithms exemplified for optimal control	



Title	Introduction to Quantum Information Theory
Number	1294540
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.

Objective qualification

The students

- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture
- acquainted with the basic objects, constructions, and mathematical theorems and their proofs of quantum information theory
- obtain an understanding of the similarities of, and the fundamental differences between, classical information theory and quantum information theory
- learn about applications of quantum information theory in quantum computing and communication.



Title	Inverse problems
Number	1294430
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.

Objective qualification

The students

- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture
- know and understand the notion of well- and ill-posedness and of regularization methods and their properties
- are able to understand, analyze and apply methods to approximately solve ill-posed problems and use them with mathematical software



Title	Continuous Optimization in Data Science
Number	1294420
ECTS	5,0
Compulsory requirements	
Compulsory	

attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - remember and understand exemplary problems in Data Science - master selected problem solving abilities using methods of continuous optimization and are able to apply them - understand theory and algorithms of continuous optimization in the context of statistical phenomena of the data basis	



Title	Machine Learning with Neural Networks
Number	1294410
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand neural networks and are able to characterize them in mathematical terms - know different use cases and applications of neural networks	

- know and understand optimization methods for the training of neural networks and are able to apply them



Title	Mathematical Foundations of Information Theory and Coding Theory
Number	1294600
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 oral exam (20-30 minutes) according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework or presentation according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
Technical/methodological skills Students understand the interconnections and complex relationships between their own mathematical knowledge and the content of the course. They understand the theory of the course as a whole and have mastered the associated methods. Students can apply and analyse the methods taught in the course and have mastered the essential fundamentals of the field. They can place individual methods in a larger context. Social skills Social skills are strengthened in particular through professional exchange among students, for example when working together to develop solution strategies, discussing mathematical concepts or cooperatively dealing with complex problems. Personal skills Students independently acquire new knowledge and perspectives and discuss mathematical content with others; they develop solutions in a focused, precise and goal-oriented manner. Students can train and improve their teamwork skills in homework assignments, compare the requirements of the module with their own prior knowledge and independently close any gaps in their knowledge, as well as reflect on their learning progress and adjust their learning behaviour if necessary.	



Title	Model Order Reduction
Number	1294500
ECTS	10,0
Compulsory requirements	
Compulsory attendance	

Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) or "Portfolio" according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - understand the concept of model reduction - know and understand the most important methods of (non)linear model reduction - are able to analyze the method and understand of the basic limits of the applicability of the methods - are able to interpret the goodness and optimality of the achievable approximation	



Title	Nonnegativity and polynomial optimization
Number	1294380
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture	

- know and understand the core statements of real algebraic geometry on nonnegativity and its relation to polynomial optimization
- know and understand the common methods in polynomial optimization in theory and practice



Title	Numerical Linear Algebra in Data Science
Number	1294360
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand the methods of linear algebra in the context of data mining - are able to analyze and evaluate problems in this field and to develop methods for their solution on the basis of the content of the lecture	



Title	Numerical Methods and Learning from Data
Number	1294350
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or "Portfolio" according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.

Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand numerical methods that are employed for Data Science applications such as Deep Learning or Machine Learning - know and understand basics of machine learning, e.g. deep neural networks	



Title	Optimization in Machine Learning and Data Analysis 1
Number	1294340
ECTS	5,0
Compulsory requirements	Knowledge of Linear Algebra, Analysis, Linear and combinatorial optimization and Discrete optimization is required, as well as basic knowledge of probability theory.
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand optimization methods for machine learning and machine learning in algorithms for optimization, in particular, discrete optimization and network optimization	



Title	Statistical and machine learning
Number	1294310
ECTS	7,0

Compulsory requirements	Mathematical knowledge in "Einführung in die Stochastik", "Wahrscheinlichkeitstheorie" and linear regression is required.
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand the basic ideas and methods in machine and statistical learning - are able to analyze and evaluate these method and apply them to practical problems	

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Title	Advanced Computerlab
Number	1294440
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	Homework according or Portfolio to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - remember and understand the basic tasks and method of mathematical algorithms and their practical application - are able to use mathematical programming tools - are able to apply, analyze and implement mathematical algorithms - are able to document and present mathematical algorithms	

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Title	Seminar Data Science - Section Mathematics
Number	1296916850
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 "Referat" according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Course achievement	
Objective qualification	
• Acquisition of social and professional skills • Competencies and skills in free speech, selected conversation techniques and selected moderation and presentation techniques • In-depth knowledge of and ability to deal with information and communication technologies • In-depth knowledge of writing mathematical-technical texts, bibliographies, excerpts and information management, as well as basics scientific reasoning • basic knowledge of the history of science of mathematics • In-depth knowledge of the societal references of mathematics (economic, political, social, ethical references) • Acquisition of action-oriented skills for communication in everyday professional life when presenting, conveying and documenting content.	



Title	Partial Differential Equations
Number	1294060
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Graded examination (Prüfungsleistung): 1 written exam (90 min.) or oral exam (30 min.) according to examiners specifications. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiners specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students are familiar with the use of ordinary differential equations for the description of engineering applications.	

They know methods to determine the quantitative and qualitative solution behaviour like the concepts of the fundamental solution, Green function and variational formulation.



Title	Ordinary Differential Equations
Number	1294050
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Graded examination (Prüfungsleistung): 1 written exam (90 min.) or oral exam (30 min.) according to examiners specifications. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiners specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students are familiar with the use of ordinary differential equations for the description of engineering applications. They know methods to determine the quantitative and qualitative solution behaviour of dynamical system and the sensitivity of the solution behaviour.	



Title	Numerical Methods for Ordinary and Partial Differential Equations
Number	1294040
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Graded examination (Prüfungsleistung): 1 written exam (90 min.) or oral exam (30 min.) according to examiners specifications. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiners specifications. The exact examination specifications will be announced at the beginning of the course.

Objective qualification

The students master the use of numerical methods for the solution of ordinary and partial differential equations, and they are able to interpret the numerical results. They know one-step and multi-step methods and the concept of step-size control. They understand the particular properties of stiff systems. The students know the methods of finite elements and of finite differences and respective adaptive procedures. They have experienced with software implementations.



Title	Mathematical Foundations of Data Science
Number	1296916020
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students are able to understand the mathematical foundations of statistical learning theory and their practical applications. They have the ability to analyze and evaluate the generalization ability of learning algorithms. The students develop a solid theoretical background for independent research and application in the fields of mathematics and data science.	



Title	Introduction into Statistical Learning Theory
Number	1296916030
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-33 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.

Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students are able to understand the mathematical foundations of statistical learning theory and their practical applications. They have the ability to analyze and evaluate the generalization ability of learning algorithms. The students develop a solid theoretical background for independent research and application in the fields of mathematics and data science.	

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Title	The Mathematics of Data Science
Number	1296105420
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
Students learn basic concepts arising in the mathematical theory of data science and the use of mathematics in it, such as linear algebra, probability theory. Exercise sessions aim at reviewing basic mathematics used in lectures and covering some topics in the mathematical side of data science related to the course. Students are required to have basic knowledge and familiarity in linear algebra and probability theory.	

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Data Science in Applications - Image and Signal Processing

Title	Mathematical Image Processing
Number	1294300
ECTS	10,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.
Objective qualification	
The students - understand the of the complex links between their previous mathematical knowledge and the contents of the lecture - understand the theoretical body of the lecture as a whole and master the corresponding methods - are able to analyze and apply the methods of the lecture - know and understand the characterization of the quality of an image through mathematical quantities - know and understand the most important basic tasks in image processing and various methods of solving them	



Title	Deep Learning for imaging in nano and quantum science
Number	1520500
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	



Title	Network Information Theory
Number	2424650
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min)
Course achievement	
Objective qualification	
After completing the lecture, the students will know the building blocks of complex communications networks, i.e., the multiple-access channel, the broadcast channel, the relay channel and the interference channel, their achievable rates and capacity regions including coding and decoding schemes. In addition, the students obtain knowledge to design future wireless and multi-hop as well as ad-hoc networks. They master information-theoretic and mathematical tools to prove coding theorems. They know the state of the art as well as open problems in network information theory.	



Title	Spoken Language Processing
Number	2424680
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Oral exam 30 minutes or written exam 90 minutes (depending on number of participants)
Course achievement	
Objective qualification	
After successful completion of the module, students will be able to classify time series (e.g., speech signals) using hidden Markov modeling. The students acquire all the necessary knowledge to suitably select, design, and evaluate methods and algorithms for automatic speech recognition to solve problems in practice.	



Title	Fundamentals of Digital Signal Processing
Number	2424760

ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	



Title	Digital Signal Processing
Number	2424770
ECTS	8,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	



Title	Computer Vision and Machine Learning
Number	4216330
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 exam: written exam, 90 minutes or oral exam, 30 minutes or Take-Home-Exam.
Course achievement	1 study achievement: 50% of the exercises must be passed

Objective qualification

Upon successful completion of this module, students will have a basic understanding of how to develop complex computer vision applications. They are able to analyze computer vision problems and to design and implement appropriate solutions.



Title	Biomedical Image and Signal Analysis
Number	4217760
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or experimental work or Portfolio or Take-Home-Exam.
Course achievement	
Objective qualification	
Passing this module, the students can classify and compare different methodologies for medical signal and image acquisition. They can differ and compare linear with non-linear filtering and analyze electrocardiography (ECG) data into their components. They can segment medical images in two and three dimensions and are able to apply model-based approaches for image and signal analytics.	



Title	Deep Learning in Remote Sensing
Number	4398860
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	
Upon completion of this module, the students will be able to understand basic principles and applications of deep learning and to apply them on Remote Sensing as well as similar problems.	



Title	Machine Learning
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Number	4398870
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	
Upon completion of this module, the students will be able to understand basic principles and applications of machine learning and to apply them on practical examples.	



Title	Computer Lab Pattern Recognition
Number	2424000020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	Development and documentation of a computer / software program
Objective qualification	
In this course, students acquire the competencies to independently select and apply appropriate machine learning and deep learning methods for complex problems. The students ... • ... master the programming language Python as well as the basics of the deep learning libraries PyTorch and Tensorflow. • ... evaluate the effectiveness of simple machine learning models and neuronal networks for classification and regression problems. • ... evaluate the quality of deep learning models on appropriate data (sub)sets with meaningful metrics • ... know and use different types of neural networks for problems in the areas of image processing, time series processing and generative problems • ... know and use different strategies for data preprocessing and data augmentation • ... know and use different training and regularization methods for the optimization of neural networks • ... evaluate the complexity of a neural network on the basis of various parameters	



Data Science in Applications - Biology, Chemistry and Pharma

Title	Immunmetabolism
Number	1398590 Bio-BB 31 / Bio-SB 31
ECTS	10,0
Compulsory requirements	none
Compulsory attendance	Attendance is compulsory for practicals, exercises, seminars, and excursions.
Expected performance/ Type of examination	- term paper - oral presentation
Course achievement	Successful participation in the practical course and seminar
Module grade composition	The module grade corresponds to the grade for the examination performance.
Objective qualification	
After completing the module, students are able to - explain the importance of the metabolism of immune cells during infection/inflammation. - apply modern analytical techniques, such as isotope labelling, mass spectrometry and metabolic flux analysis - evaluate and interpret GC-MS data. - interpret the energy metabolism by means of respiration measurements. - develop concepts for solving systems biology problems with the help of different methods. - present and discuss scientific work. - discuss controversial scientific topics and questions. - search, present and discuss relevant scientific content. - contribute to controversial discussions of scientific topics. - work successfully and independently in a team, organize a team and communicate efficiently with different target groups. - carry out advanced practical and scientific work independently and analyze experimental data. - apply in-depth foreign language skills (usually English).	



Title	CM-B-3 Elucidation and Modelling of Biological Structures
Number	1498680
ECTS	8,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	oral or written exam+ (30% of the practical work mark are taken into account in the overall module mark)
Course achievement	Practical work (marked)

Module grade composition	Practical work (marked) oral or written exam+ (30% of the practical work mark are taken into account in the overall module mark)
Objective qualification	
The students are familiar with modern methods for modelling the structure of biomacromolecules and for simulating their thermodynamic properties. They know empirical force field methods, methods for performing molecular dynamics simulations, as well as modern multiscala simulation methods. The students are able to judge the applicability and the limitations of such methods, to choose suitable simulation methods for their own research projects and to perform, analyze, and evaluate molecular dynamics simulations.	

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Title	Network Biology
Number	4217840
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam, 90 minutes, or oral exam, 30 minutes or Take-Home-Exam
Course achievement	50% of exercises must be passed
Objective qualification	
After successful completion of this module, students will have a basic understanding of graph theory and its applications for the analysis of biomedical data. They will be able to use network biology tools and critically assess network analyses. They will be capable to devise new graph-based strategies for the analysis of biomedical data.	

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Title	Biomolecular Modelling
Number	1499680 CM-B-3
ECTS	8,0
Compulsory requirements	none
Compulsory attendance	
Expected performance/ Type of examination	Oral or written exam+ (30% of the practical work mark are taken into account in the overall module mark)
Course achievement	Practical work (marked)
Module grade composition	see expected performance

Objective qualification

The students are familiar with modern methods for modelling the structure of biomacromolecules and for simulating their thermodynamic properties. They know empirical force field methods, methods for performing molecular dynamics simulations, as well as modern multiscala simulation methods. The students are able to judge the applicability and the limitations of such methods, to choose suitable simulation methods for their own research projects and to perform, analyze, and evaluate molecular dynamics simulations.



Title	Advanced Theoretical Chemistry
Number	1499170 AM-A-9
ECTS	8,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Oral or Written Exam+ (20% of the coursework and 20% of the practical work mark are taken into account in the overall module mark)
Course achievement	Solve coursework problems (unmarked) Practical work (marked)
Objective qualification	
The students have acquired knowledge on modern methods of quantum chemistry. They are familiar with the foundations of important methods and possess an overview of commonly used quantum-chemical methods, their implementation in scientific software, and their use in chemistry. They are able to judge the applicability and the limits of different quantum-chemical methods and to use choose suitable methods for their own research projects, to perform quantum-chemical calculations and to analyse, evaluate, and assess their results.	



Title	Machine Learning in Computational Chemistry
Number	1499180 AM-A-10
ECTS	8,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	oral or written exam+ (PL, 20% of the coursework and 20% of the practical work mark are taken into account in the overall module grade)
Course achievement	solve coursework problems (ÜbA, SL unmarked) practical work (expA, SL marked)
Objective qualification	
The students have acquired knowledge on modern methods of molecular machine learning and molecular artificial intelligence. They are familiar with the foundations of important methods and possess an overview of commonly used methods, their implementation, and their use in chemistry. They are able to judge the	

applicability and the limits of different methods and to use choose and apply suitable methods for their own research projects and to analyse, evaluate, and assess their results.



Title	Theoretical Spectroscopy
Number	1498120 AM-B-8
ECTS	8,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	oral or written exam+ (PL, 20% of the coursework and 20% of the practical work mark are taken into account in the overall module grade)
Course achievement	solve coursework problems (ÜbA, SL unmarked) practical work (expA, SL marked)
Objective qualification	
The students have acquired knowledge in time-dependent quantum mechanics and on modern methods of theoretical spectroscopy. They are familiar with the foundations of important methods and possess an overview of commonly used quantum-chemical methods in theoretical spectroscopy, their implementation in scientific software, and their use in chemistry. They are able to judge the applicability and the limits of different methods and to use choose suitable methods for their own research projects, to perform calculations and to analyse, evaluate, and assess their results.	



Title	Biophysical Chemistry - Applied Optical Methods and Imaging
Number	1499590
ECTS	8,0
Compulsory requirements	none
Compulsory attendance	
Expected performance/ Type of examination	Oral exam (approx. 45 min) or written exam (120 min) „Applied Optical Methods and Imaging“
Course achievement	exercises "Applied Optical Methods and Imaging"
Module grade composition	100% Oral exam oder written exam „Applied Optical Methods and Imaging“
Objective qualification	
Students are familiar with the fundamental principles of the major optical methods used to investigate biomolecules, biomolecular interactions and structures. They can assess which modern or traditional technique is best suited to answer a given biochemical question most efficiently. They understand the strengths, limitations, and dynamic range of these methods, as well as their suitability for elucidating the function, interactions, dynamics, and structure of biomolecules. Furthermore, they are able to select and evaluate appropriate	

methods for biomolecular research in both industrial and academic settings. Exemplary application areas include biotechnology, medicinal chemistry, drug discovery and development, infection research, neurobiology, and the study of photosynthetic energy conversion.

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Data Science in Applications - Business and Economics

Title	Computational Methods for Communication Science
Number	1814000010
ECTS	6,0
Compulsory requirements	
Compulsory attendance	Compulsory attendance at the module's seminar.
Expected performance/ Type of examination	1 examination requiring attendance (with permitted absences): • 1 term paper (approx. 10–15 pages) or • 1 portfolio (consisting of two to six complementary pieces of work (e.g. a talk, a poster presentation, minutes, a contribution to a debate), as well as, where applicable, a written assignment, a written examination or an oral examination to conclude the portfolio)
Course achievement	
Objective qualification	
Students acquire the ability to address communication studies issues independently and critically using computational methods. They are able to select appropriate methodological approaches, justify analytical decisions, and critically evaluate and academically document the results of data-based analyses. In addition, students develop skills in the independent organisation and execution of a research project, as well as in collaborative work within teams. They are able to structure complex analytical processes in a clear and comprehensible manner and to contextualise and communicate their findings in an appropriate way for specific audiences, even within interdisciplinary contexts.	



Title	Data Privacy & Data Governance
Number	2216010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam, 60 minutes, or oral exam, 20 minutes, or term paper or Portfolio or Take-Home-Exam
Course achievement	
Objective qualification	
The students understand the differences between the two main legal systems (case law vs. common law) in the EU. They know different sources of legal knowledge. The students are able to assess company privacy regulations and business models in relation to the legal provisions.	



Title	Empirical Economic Research
Number	2212000020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 written exam (90 mins) or 1 portfolio or 1 take-at-home exam
Course achievement	for Organisation, Governance, Education / MA Social Sciences instead of the examination performance: 1 written exam (90 mins) or 1 portfolio or 1 take-at-home exam
Objective qualification	
Students have an in-depth understanding of the fundamental methods of pooled cross-sectional and panel data analysis, as well as an overview of key time-series and machine learning methods. They are able to apply these methods in their own empirical research projects and to interpret and contextualise research findings independently. Furthermore, they are proficient in the methodologically responsible use of generative AI tools in the empirical research process – from project structuring and reproducibility to the critical evaluation of AI output.	



Title	Data Driven Decision Making
Number	2218000030
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 exam (60 min) or 1 take-at-home exam
Course achievement	Exercises (for the exercise(s)) (2.5 CP) only for Organisation, Governance, Education instead of the examination additionally 1 exam (60 min) or 1 take-at-home exam
Objective qualification	
Students develop a comprehensive understanding of the principles governing the integration of information and decision-making models into information systems. They are familiar with dynamic and stochastic modeling and solution techniques in the field of mobility. Furthermore, students can apply these techniques to new business management problems.	



Title	Business Model Innovation: Concepts and Applications
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Number	2201000040
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 portfolio or 1 take-home exam, or 1 written exam (120 mins)
Course achievement	for Organization, Governance, Education / MA Social Sciences instead of the examination performance: 1 portfolio or 1 take-home exam
Objective qualification	
Lecture & seminar required Nach Abschluss des Moduls sind die Studierenden in der Lage: To understand the fundamentals of business model innovation and to recognise the factors that play a role in the development of business model innovations. Furthermore, they will understand and be able to critically discuss how innovations are developed and which methods are appropriate for this purpose. To argue, based on theory, why certain corporate measures are expected to have an impact on innovation success. To apply methodological knowledge to develop, evaluate and critically reflect on business model innovations themselves. To formulate precise problems and research questions based on a complex practical issue in the field of innovation management, and to develop solutions using the content and methods learnt in the lecture and further methods taught in the seminar. To independently research and structure English-language academic and practical literature to support their arguments. To work on projects with other team members, critically discussing alternative approaches and reaching decisions; to demonstrate initiative in implementing the work steps; to understand complex interrelationships and present them clearly; and to present the results convincingly. Cooperate effectively in group work, reflect on individual contributions resulting from the division of labour, integrate these into a coherent overall concept, and resolve any conflicts that arise.	



Title	Advanced Multivariate Data Analysis
Number	2201000010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 written exam (120 mins) or 1 portfolio or 1 take-home exam
Course achievement	1 written exam (120 mins) or 1 portfolio or 1 take-home exam

Module grade composition	The portfolio assessment is based on a 50-50 split between the written exam and the practical exercises.
Objective qualification	
After completing this course, students will have advanced knowledge of multivariate data analysis methods in economics. They will be able to carry out and interpret multivariate data analyses using the open source software R.	

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Data Science in Applications - Engineering

Title	Ecological Modelling
Number	1116130
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Examination: Generation and documentation of computer programs
Course achievement	
Objective qualification	
After successful completion of the module, students have knowledge of the key - statistical and machine learning - methods of species distribution modelling. They also have knowledge of the most important approaches to population dynamic modelling. The students are able to apply both modelling methods for dealing with geoeological and conservation biological questions and they know the advantages and disadvantages of these methods. They are capable to visualise and interpret data and models and to check underlying assumptions as well as to evaluate parameter sensitivities.	



Title	Fundamentals of Turbulence Modeling
Number	2512380
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 Examination element: written exam (90 min) or oral exam (30 min to 45 min)
Course achievement	
Objective qualification	
Students acquire the concepts and fundamentals of engineering turbulence modeling. Students learn the underlying physics, assumptions and application of various turbulence models. They know the assumptions, governing equations, and the numerical algorithms of each methodology. Students are able to explain and evaluate the results of scale-resolution simulations in a critical way. At the end of the course, students will be able to use concepts from turbulence modeling for the solution of problems within the engineering field.	



Title	Introduction to Finite Element Methods
Number	4398470
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam (90 min) or oral exam (30 min)
Course achievement	Homework
Module grade composition	Exam 70%, homework 30%
Objective qualification	
The students know mathematical models for solid bodies and structures in engineering, especially formulations for beam, plane and volume structures. They are able to create finite element models and apply adequate solution methods.	



Title	Deep Learning in Remote Sensing
Number	4398860
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	
Upon completion of this module, the students will be able to understand basic principles and applications of deep learning and to apply them on Remote Sensing as well as similar problems.	



Title	Machine Learning
Number	4398870
ECTS	5,0
Compulsory requirements	

Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	
Upon completion of this module, the students will be able to understand basic principles and applications of machine learning and to apply them on practical examples.	



Title	Experimental Fluid Dynamics
Number	2512000030
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	
Objective qualification	
The students are able to explain mechanical, electrical and optical measurement techniques to determine fluid mechanical quantities like pressure, density, velocity, temperature and shear stress. Beyond the basic principle and the accuracy of the different measurement techniques, the students can evaluate the limitations of the techniques and use methods to improve and expand them. The students are able to apply selected measurement techniques in the laboratory course.	



Title	Data-Driven Material Modeling
Number	4398690
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course	

achievement	
Objective qualification	

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Data Science in Applications - Medicine

Title	Medical-methodological specialization module 1
Number	4217720
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded work: oral exam (30 minutes) or development and documentation of computer programs or Portfolio or Take-Home-Exam
Course achievement	
Objective qualification	
Passing this module, the students develop a fundamental understanding for methodological aspects of medical informatics. They can plan and conduct scientific studies and can develop novel research projects in the field of electronic health. The students can use, compare, and evaluate specific IT tools in medical informatics. They know about data privacy and security issues for medical data in Europe.	



Title	Medical Methodology Course 2
Number	4217730
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam (90 minutes) or oral exam (30 minutes) or Portfolio or Take-Home-Exam.
Course achievement	
Objective qualification	
Passing this module, the students have earned a fundamental understanding of the methodological aspects of medical informatics. They can plan and conduct clinical trials and apply appropriate statistics to evaluate the recorded data. They can assess the systematics of scientific research in the broad biomedical field of applied computer science. They can compare IT tools for medical statistics and significance tests.	



Title	Accident Informatics
Number	4217740
ECTS	5,0

Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded work: written exam (90 minutes) or Portfolio or Take-Home-Exam.
Course achievement	
Objective qualification	
Passing this module, the students can define the goals and perform a technical analysis of traffic accidents. They understand accident and emergency informatics on a more general level, and know the components of this novel field of research. They can use IT systems for accident research and build systems using appropriate data formats, standards, and protocols. Furthermore, they can construct scientific experiments in the field of accident and emergency informatics.	



Title	Biomedical Image and Signal Analysis
Number	4217760
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or experimental work or Portfolio or Take-Home-Exam.
Course achievement	
Objective qualification	
Passing this module, the students can classify and compare different methodologies for medical signal and image acquisition. They can differ and compare linear with non-linear filtering and analyze electrocardiography (ECG) data into their components. They can segment medical images in two and three dimensions and are able to apply model-based approaches for image and signal analytics.	



Title	Health-Enabling Technologies A
Number	4217800
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/	graded work: written exam, 90 minutes, or oral exam, 30 minutes, or Portfolio or Take-Home-Exam.

Type of examination	
Course achievement	
Objective qualification	
Passing this module, the students are able to name different health enabling technologies (HET) and explain their ethical, regulatory and social aspects. The students can use methods and tools to build HET systems.	



Title	Health-Enabling Technologies B
Number	4217810
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or Portfolio or Take-Home-Exam.
Course achievement	
Objective qualification	
Passing this module, the students can explain and compare health enabling technologies (HET). This includes knowledge and practical use of HET applications, and its underlying scientific foundation. The students are able to build HET systems using recent technologies and can plan, conduct, and analyze experiments to evaluate HET technologies.	



Title	Selected Topics of Representation and Analysis of Medical Data
Number	4217880
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam (90 minutes) or oral exam (30 minutes) or Portfolio or Take-Home-Exam
Course achievement	
Objective qualification	
The students can recall recent trends and technologies to represent and analyze medical data. They are able to compare approaches and report their key characteristics resp. differences. They can construct tools	

and scientific methodologies for data modelling and analytics. The students recognize quality criteria and can recommend specific approaches.

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Data Science in Applications - Project Work

Title	Project Work Data Science
Number	4299980
ECTS	15,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Software/program development and report on a data science project.
Course achievement	
Objective qualification	
The project thesis can serve as preparation for the master's thesis. The students are able to use scientific methods systematically to solve a complex task in the area of data science. They are able to plan the work independently and estimate the work time required. They are able to carry out the project controlling and quality assurance e.g. using milestones which they have set for themselves.	

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Key Qualifications and Ethics

Title	Ethics and Epistemology
Number	4411440
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 graded examination (Prüfungsleistung): written exam, 120 minutes
Course achievement	1 non graded examination (Studienleistung): Protokoll, 2 pages
Objective qualification	
The course: • provides a philosophical framework and moral compass for guiding the judgement of students regarding data science and its applications (artificial intelligence, robotics, etc.). • aims to develop communication skills, social and civic competences, • reassures students on the limits of machines, machinery settings, and machine ethics, • strengthens personal development in the light of digit(al)ization and related claims of social change. The students will be able to recognize and interpret social and technical problems in technology and information processing based in classical and recent position in theoretical and practical philosophy. They will be able to interpret these problems ethically and support their position with arguments from machine ethics.	



Title	Scientific and Method-Oriented Working
Number	4217000010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	According to § 7a of the APO, the purpose of this course is to help students develop social and personal skills by engaging in active participation within a small group. In particular, the course fosters skills related to academic discourse and critical reflection. Regular attendance is required in order to achieve the
Expected performance/ Type of examination	360-minute exam, portfolio, or term paper, including mandatory attendance in the course (with absences)
Course achievement	regular active participation and attendance in the course and in all group work
Module grade composition	Grade for the respective examination
Objective qualification	

Upon successful completion of the module, students will be able to independently familiarize themselves with a scientific topic, plan and document a project, and write a scientific report.

Another objective of the course is to encourage substantive and critical discussion of the presented topics, primarily through active group work. This can only be ensured through regular, active participation and attendance in class.



Title	Better Scientific Presentations and Writing
Number	4217000020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Portfolioexam
Course achievement	
Objective qualification	
Students will learn the principles of scientific writing and gain insights into how to improve their writing. They will be enabled to properly criticize existing visualizations and create new visualizations that are effective, efficient, and appropriate. They will also learn how to properly structure a talk, how to prepare adequate visual aids ("presentations"), and how oral presentations are different from written text.	



Title	Key Qualifications
Number	4298010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	An active performance record is required for the selected courses/modules (e.g. written examination, term paper, presentation, minutes). A certificate of attendance is not sufficient. The type of academic achievement depends on the module or course.
Objective qualification	
Superordinate reference/ embedding of the field of study Students will be able to classify their field of study in societal, historical, legal or professionally oriented references (depending on the focus of the course). They are able to recognize, analyze and evaluate hig-	

her-level, subject-related connections and their significance. The students acquire an insight into the net-working possibilities of the field of study and application references of their field of study in professional life.

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Master's Thesis

Title	Master's Thesis Data Science
Number	4299970
ECTS	30,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	Written thesis (final thesis) The presentation can be included in the evaluation with up to 3 of 30 credit points according to § 5 paragraph 7 (BPO)
Course achievement	
Objective qualification	
The students are able to work on a problem in the field of data science independently using scientific methods within a given time period. The following points are particularly important: - The student can familiarize themselves with the topic of the work independently. - They can systematically work on a research problem relevant to data science using scientific methods. - They are able to present the methods and the results in the form of an report. - They present the main results in an understandable form in a presentation. - They able to research literature and put their work into context.	



Title	Additional examinations
Number	1201500
ECTS	,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	



Title	
Number	2499210

ECTS	
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	
Objective qualification	

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