Brandenburgische Technische Universität Cottbus - Senftenberg
Platz der Deutschen Einheit 1, 03046 Cottbus

Brandenburgische
Technische Universität
Cottbus - Senftenberg

Modulhandbuch für den Studiengang Artificial Intelligence (universitäres Profil), Master of Science, Prüfungsordnung 2022

Inhaltsverzeichnis

Module 13600 Master Thesis

assign to: Total Account

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13600	Mandatory

Modul Title	**Master Thesis** Master-Arbeit
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	30
Learning Outcome	After successfully completing the module, students will have the ability to solve an advanced technical or scientific problem within a limited time budget under the guidance of a supervisor. They are able to use their acquired theoretical and practical knowledge to justify scientifically their solution of the problem as well as their improvments. A core aspect of the module is for the student to demonstrate that they can develop new knowledge and methods. They will have the ability to present scientific facts clearly in written and oral form.
Contents	The task can be of practical or theoretical nature and should correspond to challenging problems occurring in working life. To solve the task, the knowledge and methods from previous courses and the current scientific literature are to be applied and improved. The technical content of the task is determined by the student's mentor.
Recommended Prerequisites	none
Mandatory Prerequisites	• Internship • at least 78 credit points See examination and study regulation Artificial Intelligence M.Sc. §8 (2)
Forms of Teaching and Proportion	Research paper/essay - 870 hours Seminar - 2 hours per week per semester
Teaching Materials and Literature	Literature references are provided by the supervisor at the beginning of the project.

	The supervisor will also provide tools, equipment and documentation, depending on the topic.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Written master thesis, graded by at least two examinators, 75% of grade • Oral presentation and examination (defense), 25% of grade
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Mandatory module The duration of writing the thesis is limited to 24 weeks.
Module Components	• Consultations (according to agreement) • When required intermediate presentation at a seminar • Final presentation (defense)
Components to be offered in the Current Semester	**100046** Seminar Seminar Computing at Scale in Machine Learning - 2 Hours per Term **100052** Seminar Oberseminar Medizinische Bioinformatik - 2 Hours per Term **100042** Practical training Laboratory: Workflows for Machine Learning and Reproducible Science - 2 Hours per Term **100051** Practical training Laboratory Bioinformatics - 2 Hours per Term

Module 13602 Internship

assign to: Total Account

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13602	Mandatory

Modul Title	**Internship** Berufspraktikum
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	10
Learning Outcome	After successfully completing the module, students will have the ability to solve a subtask of a larger project in a professional environment and to document the results. In particular the students will be acquainted with work processes and group organization in professional environments. They will be able to apply their acquired practical and theoretical knowledge in the working world and to assess the relevance of scientific approaches.
Contents	A time-limited task is handled by methods of computer science in an external facility. The task is assigened by the external facility in agreement between the student's mentor and the external supervisor.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Practical training - 270 hours Research paper/essay - 30 hours
Teaching Materials and Literature	Working materials, references, documentation will be provided by supervising facility.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Internship report, 3500 to 4000 words

	The internship report has to be delivered not later than 8 weeks after completion of the internship. It is examined by the student's mentor.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Mandatory module See study regulations for Artificial Intelligence M.Sc. §6 as well as the special internship regulations for the study programme „Artificial Intelligence“. At the beginnig of the internship the internship employer has to specify a supervisor.
Module Components	• Consultations, according to agreement
Components to be offered in the Current Semester	No assignment

Modul 11102 Lineare Algebra und analytische Geometrie II

zugeordnet zu: Advanced Methods

Studiengang Artificial Intelligence

Akademischer Grad	Modulnummer	Modulform
Master of Science	11102	Wahlpflicht

Modultitel	**Lineare Algebra und analytische Geometrie II** Linear Algebra and Analytical Geometry II
Einrichtung	Fakultät 1 - MINT - Mathematik, Informatik, Physik, Elektro- und Informationstechnik
Verantwortlich	Prof. Dr. rer. nat. habil. Köhler, Ekkehard
Lehr- und Prüfungssprache	Deutsch
Dauer	1 Semester
Angebotsturnus	jedes Sommersemester
Leistungspunkte	8
Lernziele	Die Studierenden sollen • die im Modul Lineare Algebra und Analytische Geometrie I erworbenen Kenntnisse und Fähigkeiten erweitern • weitere sichere Kenntnisse über grundlegende Begriffe und Sätze zu Matrizen, Vektoren und algebraische Strukturen erwerben • Basiswissen für vertiefende Module erwerben • wichtige Matrix-Algorithmen, insbesondere der Orthogonalisierung und der Diagonalisierung, beherrschen • die mathematischen Grundfertigkeiten, wie exaktes Formulieren und formelles Aufbereiten mathematischer Schlussketten, vertiefen • ihr Verständnis für Bedeutung und Nutzen und Anwendung von algebraischen Strukturen erweitern • mathematische Grundfertigkeiten, wie exaktes Formulieren und formelles Aufbereiten einfacher mathematischer Sachverhalte, erwerben • Fertigkeiten in den grundlegenden Beweistechniken weiter entwickeln • grundlegende Fähigkeiten im exakten logischen Schließen entwickeln • zur Analyse abstrakter Strukturen befähigt werden • insbesondere durch eigenständiges Lösen von Übungsaufgaben zur Exaktheit in der Umsetzung des Faktenwissens aus den Lehrveranstaltungen befähigt werden • dabei individuelle Lernstrategien zur selbstständigen Aneignung mathematischer Inhalte entwickeln (effektive Kombination von Vorlesung, Übung, Selbststudium) • zur selbstständigen Nutzung mathematischer Fachliteratur als Ergänzung der Lehrveranstaltungen befähigt werden

	• am Beispiel von Themen der linearen Algebra sicheres Basiswissen und Fertigkeiten für das weitere Mathematikstudium erwerben und an das selbstständige wissenschaftliche Arbeiten herangeführt werden.
Inhalte	• Eigenwerte und Eigenräume • Diagonalisierbarkeit von Operatoren • symmetrische und alternierende Bilinearformen • Euklidische und unitäre Vektorräume • orthogonale Abbildungen • Hauptachsentransformation • einige Normalformen von Matrizen • Dualität und Restklassenräume • Zusammenfassung der wichtigsten algebraischen Strukturen und von universellen Konstruktionen
Empfohlene Voraussetzungen	Kenntnis des Stoffes von Modul • 11101: Lineare Algebra und analytische Geometrie I
Zwingende Voraussetzungen	keine
Lehrformen und Arbeitsumfang	Vorlesung - 4 SWS Übung - 2 SWS Selbststudium - 150 Stunden
Unterrichtsmaterialien und Literaturhinweise	• Fischer, Gerd: Lineare Algebra, Vieweg • Jänich, Klaus: Lineare Algebra, Springer • Kowalski/Michler: Lineare Algebra, de Gruyter
Modulprüfung	Voraussetzung + Modulabschlussprüfung (MAP)
Prüfungsleistung/en für Modulprüfung	**Voraussetzung für die Modulabschlussprüfung:** • erfolgreiche Bearbeitung von Hausaufgaben **Modulabschlussprüfung:** • Klausur, 90 min. **ODER** • mündliche Prüfung, 30 min. In der ersten Lehrveranstaltung wird bekanntgegeben, ob die Prüfungsleistung in schriftlicher oder mündlicher Form zu erbringen ist.
Bewertung der Modulprüfung	Prüfungsleistung - benotet
Teilnehmerbeschränkung	keine
Bemerkungen	• Studiengang Mathematik B.Sc.: Pflichtmodul im Komplex „Grundlagen“ • Studiengang Wirtschaftsmathematik B.Sc.: Pflichtmodul im Komplex „Grundlagen“ • Studiengang Informatik B.Sc.: Wahlpflichtmodul im Komplex „Praktische Mathematik“ oder im Anwendungsfach „Mathematik“ • Studiengang Informatik M.Sc.:Wahlpflichtmodul im Komplex „Mathematik“ oder im Anwendungsfach „Mathematik“ • Studiengang Physik B.Sc.: Wahlpflichtmodul im Komplex „Mathematik“

Veranstaltungen zum Modul	• Vorlesung: Lineare Algebra und analytische Geometrie II • Übung zur Vorlesung • Zugehörige Prüfung
Veranstaltungen im aktuellen Semester	**130410** Vorlesung Lineare Algebra und analytische Geometrie II - 4 SWS **130411** Übung Lineare Algebra und analytische Geometrie II - 2 SWS **130412** Prüfung Lineare Algebra und analytische Geometrie II

Modul 11104 Analysis II

zugeordnet zu: Advanced Methods

Studiengang Artificial Intelligence

Akademischer Grad	Modulnummer	Modulform
Master of Science	11104	Wahlpflicht

Modultitel	**Analysis II** Analysis II
Einrichtung	Fakultät 1 - MINT - Mathematik, Informatik, Physik, Elektro- und Informationstechnik
Verantwortlich	Prof. Dr. rer. nat. habil. Wachsmuth, Gerd
Lehr- und Prüfungssprache	Deutsch
Dauer	1 Semester
Angebotsturnus	jedes Sommersemester
Leistungspunkte	8
Lernziele	Die Studierenden • erweitern die im Modul Analysis I erworbenen Kenntnisse und Fähigkeiten • kennen weitere grundlegende Begriffe und Sätze der Differential- und Integralrechnung sicher • beherrschen die elementaren Verfahren der Analysis für Funktionen einer und mehrerer Variablen sicher • können Grundaufgaben der Differential- und Integralrechnung sicher lösen • beherrschen mathematische Grundfertigkeiten, wie exaktes Formulieren und formelles Aufbereiten einfacher mathematischer Sachverhalte • entwickeln Fertigkeiten in den grundlegenden Beweistechniken weiter • entwickeln grundlegende Fähigkeiten im exakten logischen Schließen entwickeln • sind zur Analyse abstrakter Strukturen befähigt • insbesondere durch eigenständiges Lösen von Übungsaufgaben zur Exaktheit in der Umsetzung des Faktenwissens aus den Lehrveranstaltungen befähigt werden • entwickeln dabei individuelle Lernstrategien zur selbstständigen Aneignung mathematischer Inhalte (effektive Kombination von Vorlesung, Übung, Selbststudium) • sind zur selbstständigen Nutzung mathematischer Fachliteratur als Ergänzung der Lehrveranstaltungen befähigt • werden herangeführt am Beispiel von Themen der Analysis sicheres Basiswissen und Fertigkeiten für das weitere Mathematikstudium erwerben und an das selbstständige wissenschaftliche Arbeiten

Inhalte	• **Fortsetzung Differentialrechnung in mehreren Veränderlichen** Partielle Ableitungen, totales Differential; Fehlerrechnung, Extrema von Funktionen mehrerer Veränderlicher, Lagrangesche Multiplikatorenmethode Taylorentwicklung, Auflösungssätze • **Das Riemannsche einfache Integral** Integralbegriff, Integrationsmethoden uneigentliche Integrale, Parameterintegrale • **Funktionenfolgen und Reihen** Gleichmäßige und punktweise Konvergenz, Differentiation und Integration • **Elementare Integrationsmethoden für gewöhnliche Differentialgleichungen 1. Ordnung** lineare Differentialgleichung, Trennung der Veränderlichen
Empfohlene Voraussetzungen	Kenntnis des Stoffes des Moduls • 11103: Analysis I
Zwingende Voraussetzungen	keine
Lehrformen und Arbeitsumfang	Vorlesung - 4 SWS Übung - 2 SWS Selbststudium - 150 Stunden
Unterrichtsmaterialien und Literaturhinweise	• Günther u. a. : Grundkurs Analysis I und II, B. G. Teubner Stuttgart, 1973 • Heuser, H.: Lehrbuch der Analysis I und II, B. G. Teubner Stuttgart, 1994 • Hildebrandt, S.: Analysis 1 und 2, Springer-Verlag, 2002/03 • Sauvigny, F. : Einführung in die reelle und komplexe Analysis mit ihren gewöhnlichen Differentialgleichungen 1 & 2. Vorlesungsskriptum an der BTU Cottbus im Wintersemester 2006/07 und im Sommersemester 2007.
Modulprüfung	Voraussetzung + Modulabschlussprüfung (MAP)
Prüfungsleistung/en für Modulprüfung	**Voraussetzung für die Modulabschlussprüfung:** • erfolgreiche Bearbeitung von Hausaufgaben **Modulabschlussprüfung:** • Klausur, 90 min. **ODER** • mündliche Prüfung, 30 min. (bei geringer Teilnehmerzahl) In der ersten Lehrveranstaltung wird bekanntgegeben, ob die Prüfungsleistung in schriftlicher oder mündlicher Form zu erbringen ist.
Bewertung der Modulprüfung	Prüfungsleistung - benotet
Teilnehmerbeschränkung	keine
Bemerkungen	• Studiengang Mathematik B.Sc.: Pflichtmodul im Komplex „Grundlagen“ • Studiengang Wirtschaftsmathematik B.Sc.: Pflichtmodul im Komplex „Grundlagen“ • Studiengang Physik B.Sc.: Pflichtmodul im Komplex „Mathematik

- Studiengang Informatik B.Sc.: Wahlpflichtmodul im Komplex „Praktische Mathematik“ oder im Anwendungsfach „Mathematik“
- Studiengang Informatik M.Sc.:Wahlpflichtmodul im Komplex „Mathematik“ oder im Anwendungsfach „Mathematik“

Veranstaltungen zum Modul

- Vorlesung: Analysis II
- Übung zur Vorlesung
- Zugehörige Prüfung

Veranstaltungen im aktuellen Semester

130130 Vorlesung
Analysis II - 4 SWS
130131 Übung
Analysis II - 2 SWS
130133 Prüfung
Analysis II

Modul 11201 Analysis III

zugeordnet zu: Advanced Methods

Studiengang Artificial Intelligence

Akademischer Grad	Modulnummer	Modulform
Master of Science	11201	Wahlpflicht

Modultitel	**Analysis III** Analysis III
Einrichtung	Fakultät 1 - MINT - Mathematik, Informatik, Physik, Elektro- und Informationstechnik
Verantwortlich	Prof. Dr. rer. nat. habil. Wachsmuth, Gerd
Lehr- und Prüfungssprache	Deutsch
Dauer	1 Semester
Angebotsturnus	jedes Wintersemester
Leistungspunkte	8
Lernziele	Die Studierenden sollen • erweitern die in den Modulen Analysis I und II erworbenen Kenntnisse und Fähigkeiten • kennen die Theorie der gewöhnlichen Differentialgleichungen, der Vektoranalysis und der Integrationstheorie im n-dimensionalen Raum sicher • besitzen Basiswissen für vertiefende Module • beherrschen die analytischen Verfahren der Lösung gewöhnlicher Differentialgleichungen sicher • beherrschen die Methoden zur Berechnung von Integralen im n-dimensionalen Raum sicher • beherrschen die Verfahren der Vektoranalysis sicher • erweitern Fähigkeiten und Fertigkeiten in der Führung von Beweisen • verbessern Abstraktionsvermögen weiter • sind insbesondere durch eigenständiges Lösen von Übungsaufgaben zur Exaktheit in der Umsetzung des Faktenwissens aus den Lehrveranstaltungen befähigt • entwickeln dabei individuelle Lernstrategien zur selbstständigen Aneignung mathematischer Inhalte (effektive Kombination von Vorlesung, Übung, Selbststudium) • erweitern Fähigkeiten im selbstständigen wissenschaftlichen Arbeiten, insbesondere in der selbstständigen Nutzung mathematischer Fachliteratur als Ergänzung zu den Lehrveranstaltungen.
Inhalte	• Existenz und Eindeutigkeit von Lösungen gewöhnlicher Differentialgleichungen erster Ordnung (Satz von Peano und Picard-Lindelöf, mit Beweisen).

	• Sätze über stetige und differenzierbare Abhängigkeit der Lösung von Parametern und Anfangswerten. • Elementare Lösungsverfahren. • Lineare Differentialgleichungen höherer Ordnung und Systeme. • Gebiets-, Kurven- und Oberflächenintegrale mit Anwendungen in Geometrie und Physik. • Integralsätze (Gauß, Stokes, Greensche Formeln) • Einführung des Lebesgueschen Integrals.
Empfohlene Voraussetzungen	Kenntnis des Stoffes der Module • 11103 : Analysis I • 11104 : Analysis II
Zwingende Voraussetzungen	keine
Lehrformen und Arbeitsumfang	Vorlesung - 4 SWS Übung - 2 SWS Selbststudium - 150 Stunden
Unterrichtsmaterialien und Literaturhinweise	• Heuser, H.: Gewöhnliche Differentialgleichungen, Teubner Stuttgart, 1991. • Sauvigny, F.:Einführung in die reelle und komplexe Analysis mit ihren gewöhnlichen Differentialgleichungen 2. Vorlesungsskriptum an der BTU Cottbus im Sommersemester 2007. • Sauvigny, F.: Partielle Differentialgleichungen der Geometrie und der Physik 1 - Grundlagen und Integraldarstellungen, insbesondere Kapitel I und II, Springer Berlin, 2004. • Walter, W.: Gewöhnliche Differentialgleichungen, Springer Berlin, 1996.
Modulprüfung	Voraussetzung + Modulabschlussprüfung (MAP)
Prüfungsleistung/en für Modulprüfung	**Voraussetzung für die Modulabschlussprüfung:** • erfolgreiche Bearbeitung von Hausaufgaben **Modulabschlussprüfung:** • Klausur, 90 min. **ODER** • mündliche Prüfung, 30 min. (bei geringer Teilnehmerzahl) In der ersten Lehrveranstaltung wird bekanntgegeben, ob die Prüfungsleistung in schriftlicher oder mündlicher Form zu erbringen ist.
Bewertung der Modulprüfung	Prüfungsleistung - benotet
Teilnehmerbeschränkung	keine
Bemerkungen	• Studiengang Mathematik B.Sc.: Pflichtmodul im Komplex „Grundlagen“ • Studiengang Wirtschaftsmathematik B.Sc.: Pflichtmodul im Komplex „Grundlagen“
Veranstaltungen zum Modul	• Vorlesung Analysis III • Übung Analysis III • Prüfung Analysis III

Veranstaltungen im aktuellen Semester keine Zuordnung vorhanden

Module 11212 Statistics

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	11212	Compulsory elective

Modul Title	**Statistics** Statistik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Wunderlich, Ralf Prof. Dr. rer. nat. Hartmann, Carsten
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	• Aquirement of basic knowledge and skills in Probability Theory and Mathematical Statistics • Qualifying for solving typical problems from engineering using statistical methods and for critical interpretation of results of statistical investigation The lectures give theoretical fundamentals and explain them at typical examples from engineering. Exercises aim to deepen this knowledge and to apply it at further typical situations. Homework sheets, to be solved independently, serve for further consolidation, deeepening and enhancement of lecture and exercise contents.
Contents	Introduction to fundamentals of probability theory and mathematical statistics: random variables and their distributions (discrete and continuous), limit theorems, laws of large number, point and interval estimations, significance tests (parametric as well as non-parametric for one or two samples), correlation and regression analysis
Recommended Prerequisites	Knowledge of subject matters from the modules • 11110: Mathematics of Engineering I • 11111: Mathematics of Engineering II
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Smith, P. J. : Into Statistics, Springer (Singapore) 1998 • Montgomery, D. C./ Runger, G. C.: Applied Statistics and Probability for Engineers, John Wiley Sons, • Inc. 1994 • Frank, H./ Althoen, S. C.: Statistics, Concepts and Applications, Cambridge University Press 1994 • McClave, J. T.: A First Course in Business Statistics, Prentice Hall 2001 • McClave, J. T./ Sincich, T. L.: A First Course in Statistics, Prentice Hall 2002
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of homework **Final module examination:** • Written examination, 90 min. or oral examination, 30 min. + preparation time The type (written or oral) will be anounced at the beginning of the lecture period.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in the complex „Advanced Methods“
Module Components	• Lecture Statistics • Exercise Statistics • Tutorial Statistics • Examination Statistics
Components to be offered in the Current Semester	**130060** Examination Statistics (Wiederholung)

Modul 11289 Softwaretechnik

zugeordnet zu: Advanced Methods

Studiengang Artificial Intelligence

Akademischer Grad	Modulnummer	Modulform
Master of Science	11289	Wahlpflicht

Modultitel	**Softwaretechnik** Software Engineering
Einrichtung	Fakultät 1 - MINT - Mathematik, Informatik, Physik, Elektro- und Informationstechnik
Verantwortlich	Prof. Dr. rer. nat. Lambers, Leen
Lehr- und Prüfungssprache	Deutsch
Dauer	1 Semester
Angebotsturnus	jedes Sommersemester
Leistungspunkte	8
Lernziele	Nach erfolgreichem Abschluss des Moduls besitzen die Studierenden Kenntnisse von fortgeschrittenen Methoden und Werkzeugen zur Softwareentwicklung. Sie sind befähigt zur Auswahl, Anwendung und Evaluierung von Methoden und Werkzeuge zur Softwareentwicklung. Sie sind befähigt zur selbständigen Erarbeitung und Präsentation von Spezialwissen im Themenfeld Softwaretechnik.
Inhalte	• Fortgeschrittene Methoden und Werkzeuge für Analyse und Entwurf, Implementierung, Wartung und Qualitätssicherung von Softwaresystemen • Ethische und gesellschaftliche Aspekte in Verbindung mit Softwaretechnik
Empfohlene Voraussetzungen	Kenntnis des Stoffes der Module • 12101: Algorithmieren und Programmieren • 12104: Entwicklung von Softwaresystemen • 12202: Softwarepraktikum
Zwingende Voraussetzungen	keine
Lehrformen und Arbeitsumfang	Vorlesung - 4 SWS Übung - 2 SWS Selbststudium - 150 Stunden
Unterrichtsmaterialien und Literaturhinweise	• Helmut Balzert. Lehrbuch der Softwaretechnik, Band 1/2. Spektrum Akademischer Verlag, 2005 • Ian Sommerville, Software Engineering, 10. Auflage, Pearson, 2018

	• Ian Sommerville, Modernes Software Engineering, Pearson, 2020 • Software Testing and Analysis: Process, Principles and Techniques; Mauro Pezzè, Michal Young, Wiley, 2007
Modulprüfung	Voraussetzung + Modulabschlussprüfung (MAP)
Prüfungsleistung/en für Modulprüfung	**Voraussetzung für die Modulabschlussprüfung:** • erfolgreiche Bearbeitung von Übungsaufgaben erfolgreicher Präsentation der Ergebnisse in den Übungen (75% müssen erbracht/ gelöst werden) **Modulabschlussprüfung:** • Klausur, 90 min. **ODER** • mündliche Prüfung, 30-45 min. In der ersten Lehrveranstaltung wird bekanntgegeben, ob die Prüfungsleistung in schriftlicher oder mündlicher Form zu erbringen ist.
Bewertung der Modulprüfung	Prüfungsleistung - benotet
Teilnehmerbeschränkung	keine
Bemerkungen	• Studiengang Informatik M.Sc.: Wahlpflichtmodul in Komplex „Praktische Informatik“ (Niveaustufe 400) • Studiengang Künstliche Intelligenz Technologie M.Sc.: Wahlpflichtmodul im Komplex „Software-basierte Systeme“ • Studiengang eBusiness M.Sc.: Wahlpflichtmodul im Komplex „Entwicklung und Aufbau von eBusiness-Systemen“ • Studiengang Angewandte Mathematik M.Sc.: Wahlpflichtmodul im Anwendungsfach „Informatik“ • Studiengang Artificial Intelligence M.Sc.: Wahlpflichtmodul im Komplex „Advanced Methods"
Veranstaltungen zum Modul	• Vorlesung: Softwaretechnik • Übung zur Vorlesung • Zugehörige Prüfung
Veranstaltungen im aktuellen Semester	**120630** Vorlesung Softwaretechnik - 4 SWS **120631** Übung Softwaretechnik - 2 SWS **120632** Prüfung Softwaretechnik

Module 11859 Cryptography

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	11859	Compulsory elective

Modul Title	**Cryptography** Kryptographie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil Meer, Klaus Prof. Dr. rer. nat. Averkov, Gennadiy
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	8
Learning Outcome	The students should • know relevant symmetric and asymmetric crypto systems • understand the mathematics relevant for desgining and analyzing crypto systems • be able to explain and use the most important approaches to cryptography • gain the ability to understand state-of-the-art scientific work in the area of cryptography
Contents	• Mathematical Foundations relevant in the context of cryptography, including basic number theory, finite fields, polynomial rings, factorization • elementary crypto systems • Symmetric Cryptosystems DES and AES • public key cryptography, RSA - discrete logarithm, elliptic curve systems • secure signature and authentication methods • security of crypto systems • zero knowledge proofs • complexity theoretic aspects
Recommended Prerequisites	Basic knowledge about discrete mathematics and linear algebra, for example as covered by the modules • 11101: Lineare Algebra und analytische Geometrie I • 11102: Lineare Algebra und analytische Geometrie II

	or • 11112: Mathematik IT-1 (Diskrete Mathematik) • 11113: Mathematik IT-2 (Lineare Algebra)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	**Books in English** • G. Baumslag, B. Fine, M. Kreuzer, G. Rosenberger: A Course in Mathematical Cryptography, De Gruyter, 2015 • J. Hoffstein, J. Pipher, J.H. Silverman: An Introduction to Mathematical Cryptography, 2nd Edition, Springer 2014. • D.R. Stinson: Cryptography: Theory and Practice, CRC, 1995 **Books in German** • V. Diekert, M. Kufleitner, G. Rosenberger: Diskrete Algebraische Methoden, De Gruyter 2013
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of homework (fortnightly) and/or successful completion of tests (approx. 4 tests of 15-30 minutes each, written during the lecture period) **Final module examination:** • Written examination, 90 minutes, **OR** • Oral examination, 30 - 45 minutes, (in case of a small number of participants) In the first lecture it will be anounced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	80
Remarks	• Study programme Cyber Security M.Sc.: Mandatory module in complex „Cyber Security Basics“ • Study programme Informatik M.Sc.: Compulsory elective module in complex „Mathematik“ or in field of application „Mathematik“ • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanced Methods“ • Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Kombinatorik“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Physics M. Sc.: Compulsory elective module in complex „Minor Subject"

- Study programme Mathematics M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Combinatorics“
- Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“

Module Components

- Lecture: Cryptography
- Accompanying exercises
- Related examination

Components to be offered in the Current Semester

130230 Lecture
Cryptography - 4 Hours per Term
130231 Exercise
Cryptography - 2 Hours per Term
130233 Tutorial
Cryptography - 2 Hours per Term
130232 Examination
Cryptography

Module 11886 Dependability and Fault Tolerance

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	11886	Compulsory elective

Modul Title	**Dependability and Fault Tolerance** Zuverlässigkeit und Fehlertoleranz
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Dr.-Ing. habil. Herglotz, Christian Josef
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students learn to regard and to analyze digital circuits and systems with respect to their reliability and dependability. They also learn how to implement mechanism for a fault tolerant behaviour into digital circuits and systems.
Contents	Introduction: Problems of system reliability and dependability. Chapter 1: Faults and fault mechanisms in digital circuits and systems. Chapter 2: Technologies for IC production testing. Chapter 3: Methods for built-in self test (off-line). Chapter 4: Methods and Architectures for on-line fault detection and compensation. Chapter 5: Basic architectures for reconfigurable and self-repairing circuits and systems Chapter 6: Challenges in AI Hardware Systems
Recommended Prerequisites	Basic knowledge in digital design, electrical engineering and integrated electronics.
Mandatory Prerequisites	No successful participation in module • 12476 *Zuverlässigkeit und Fehlertoleranz*.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Laboratory training - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	Script and presentations available for downloading. List of references is presented at the beginning of the course. Problems for exercises and instructions for lab experiments can be downloaded.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of exercises and presentation of results in course **Final module examination:** • Oral examination, 30-45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex "Angewandte und Technische Informatik" (level 400) • Study programme Cyber Security M.Sc.: Compulsory elective module in complex "Computer Science" • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Hardware-basierte Systeme: Elektrotechnik, Informationstechnik und Sensorik“
Module Components	• Lecture: Dependability and Fault Tolerance • Accompanying laboratory • Related examination
Components to be offered in the Current Semester	**120485** Examination Dependability and Fault Tolerance

Module 12973 Network and System Security

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	12973	Compulsory elective

Modul Title	**Network and System Security** Netzwerk- und Systemsicherheit
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Panchenko, Andriy
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students will get familiar with challenges in securing computer systems and networks. They will get acquainted with fundamental security and privacy concepts that will be used as building blocks for later specialization.
Contents	In the scope of this module, we explore, among others, the following topics: • Anonymity and Privacy (mixes, onion routing, Tor • Firewalls • Malware, Botnets, and Intrusion Detection • Exploits • Wireless Security • Physical Security • Biometrics • Access Control • Electronic Payments • E-voting • Digital Rights Management
Recommended Prerequisites	Knowledge of the contents of modules • 11859 *Kryptographie* • 11889 *Einführung in die IT-Sicherheit*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	Provided on the homepage of the chair.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful treatment of all assigned project tasks including successful presentation of the results **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be anounced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Cyber Security M.Sc.: Compulsory elective module in complex „Cyber Security Methods“ • Study programme Informatik M.Sc.: Compulsory elective module in complex „Angewandte und technische Informatik“ (level 400) • Study programme eBusiness M.Sc.: Compulsory elective module in complex „Entwicklung und Aufbau von eBusiness-Systemen“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Hardware-basierte Systeme: Elektrotechnik, Informationstechnik und Sensorik“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“
Module Components	• Lecture: Network and System Security • Accompanying exercises • Related examination
Components to be offered in the Current Semester	**120510** Lecture Network and System Security - 2 Hours per Term **120511** Exercise Network and System Security - 2 Hours per Term **120512** Examination Network and System Security

Module 13220 Modeling in Mixed-Integer Optimization

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13220	Compulsory elective

Modul Title	**Modeling in Mixed-Integer Optimization** Gemischt-ganzzahlige Modellbildung
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fügenschuh, Armin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	After successful completion of the module, students will be able to recognise and evaluate the application possibilities of modeling languages for the formulation of optimization problems. They can formulate models within a modeling language and select suitable numerical solvers for their solution. They are able to interpret the solution in the application context.
Contents	• Modeling in mixed-integer optimization. • Modeling alternatives. • Basics of modeling languages. • Detailed presentation of individual languages, such as AMPL, GAMS and AIMMS for the formulation of mathematical optimization tasks.
Recommended Prerequisites	Knowledge in linear and mixed-integer optimization, e.g. knowledge of the content of • module 11312 : Optimization I or • module 11322 : Optimization Methods in Operations Research
Mandatory Prerequisites	No successful participation in German speaking module *12701 - Gemischt-ganzzahlige Modellbildung.*
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 165 hours

Teaching Materials and Literature	Corresponding to the respective focus, literature will be announced at the beginning of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 written examinations, 30 minutes each, of which the best 3 contribute to the final module grade with a weighting of 1/3 each.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Applied Mathematics M.Sc.: Compulsory elective module in complex „Optimization“ • Study programme Mathematics B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Economathematics B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ For the different modeling languages software packages are installed on students' laptops. Required operating systems: MacOS / Linux and Windows (for the language AIMMS). If there is no need that the module 12701 „Gemischt-ganzzahlige Modellbildung“ is taught in German, alternatively this English version 13220 may be offered instead.
Module Components	• Lecture with integrated exercises: Gemischt-ganzzahlige Modellbildung • Related examination
Components to be offered in the Current Semester	No assignment

Module 13490 Secure Cyber-Physical Systems

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13490	Compulsory elective

Modul Title	**Secure Cyber-Physical Systems** Sichere Cyber-Physische Systeme
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Panchenko, Andriy
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students can assess and master the challenges in securing cyber-physical systems and industrial control networks. They have deepened their knowledge of the module “Introduction to Cybersecurity“. They understand the principles of system and network security with a special focus on cyber-physical systems. They know the security and privacy concepts as building blocks for the later specialization.
Contents	Cyber-physical systems (CPS) are closely connected to their environment via sensors and actuators. It is "the fusion of reality with the network". They comprise of a A/D and D/A converters to sense and interact, to influence the physical environment in a coordinated way. The spectrum of CPS ranges from medical devices (e.g., pace makers), smart vehicles up to countrywide industrial control networks (e.g., energy networks, smart grids). Functioning of our society depends on the cyber-physical systems. This course is the continuation of the Introduction into Cyber Security and covers principles of system and network security with a special focus on cyber-physical systems. It introduces security and privacy concepts as building blocks for later specialization. In the scope of this module, we explore, among others, the following topics: • Introduction and General Security Concepts • The World of Cyber-Physical Systems • Industrial Protocols • Definitions, Security Goals, Attacker Models • Physical Security

	• Access Control • Isolation Mechanisms • Firewalls • Anomaly and Intrusion Detection • Honeypots • Fingerprinting Techniques • Security Protocols • Malware
Recommended Prerequisites	Knowledge of the material of the modules • 11889 *Einführung in die IT-Sicherheit* • 12973 *Netzwerk- und Systemsicherheit* (can be taken in parallel)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Gollmann: Computer Security, Wiley & Sons • William Stallings, Lawrie Brown: Computer Security: Principles and Practice, Pearson • Du: Computer & Internet Security: A Hands-on Approach Additional information will be provided at the begin of the module.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful treatment of all assigned project tasks (usually about 3-5 tasks) including successful presentation of the results in the laboratory course (approx. 15 minutes per task) **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be anounced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Cyber Security M.Sc.: Compulsory elective module in complex „Cyber Security Methods“ • Study programme Informatik M.Sc.: Compulsory elective module in complex „Angewandte und technische Informatik“ (level 400) • Study programme eBusiness M. Sc.: Compulsory elective module in complex „Entwicklung und Aufbau von eBusiness-Systemen“ • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme“

Module Components	• Lecture: Secure Cyber-Physical Systems • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**120550** Lecture Secure Cyber-Physical Systems - 2 Hours per Term **120551** Exercise Secure Cyber-Physical Systems - 2 Hours per Term **120552** Examination Secure Cyber-Physical Systems

Module 13843 Scientific Computing

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13843	Compulsory elective

Modul Title	**Scientific Computing** Methoden des Scientific Computing
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Breuß, Michael Prof. Dr.-Ing. Oevermann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	After successfully completing the module, students will have extended the knowledge and skills acquired in the previous numerical modules. They will have acquired advanced knowledge for understanding modern simulation methods in a wide variety of areas of science and technology.
Contents	The aim of the module is to introduce advanced methods used in scientific computing. The main part of the course is devoted to the discretization of partial differential equations. Among the topics are: The variety of discrete grid types used in discretizations, Finite-Element-Methods, Finite-Volume-Methods, special Finite-Difference-Methods, a variety of time stepping methods for time-dependent partial differential equations, TVD-Schemes for hyperbolic conservation laws, iterative solvers for sparse linear systems of equations.
Recommended Prerequisites	Knowledge of the content of the modules: • 11925 *Grundlagen der Numerischen Mathematik* • 11943 *Grundlagen des Wissenschaftlichen Rechnens* • 11414 *Funktionentheorie und Partielle Differentialgleichungen* as well as programming skills, typically Matlab and C / Fortran
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester

	Practical training - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	The literature in use may change over time and will be announced at the first class meeting.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of homework **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30 min. In the first lecture it will be anounced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Numerics“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Numerics“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science“
Module Components	• Lecture: „Scientific Computing“ • Accompanying exercise • Accompanying laboratory • Related examination
Components to be offered in the Current Semester	**130393** Examination Scientific Computing

Module 13844 Functional Analysis

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13844	Compulsory elective

Modul Title	**Functional Analysis** Funktionalanalysis
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Wachsmuth, Gerd
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	The students have • expanded and intensified their knowledge from previous modules of Analysis and Algebra • competently mastered definitions and interrelations within abstract spaces • become acquainted with applications in Numerics, Optimization, and Physics • acquired basic knowledge for advanced modules • became familiar with fundamental techniques of proof • improved their logical way of thinking by solving problems in abstract spaces • further developed their abilities for independent scientific work by treating themes from Functional Analysis
Contents	• **Normed spaces** completion, separable spaces, Lebesgue spaces, spaces of continuous and differentiable functions, Sobolev spaces • **Linear and continuous operators** Projection and adjoint operators, topological dual spaces, completely continuous operators, weak convergence and reflexivity • **Main theorems** Weierstrass, Hahn-Banach, Schauder, the openmapping, the closed graph • **Hilbert spaces** Spectral theorem for selfadjoint, completely continuous operators
Recommended Prerequisites	Knowledge of the content of the modules

- 11103 *Analysis I*
- 11104 *Analysis II*
- 11201 *Analysis III*

Mandatory Prerequisites

No successful participation in module *11303 - Funktionalanalysis*.

Forms of Teaching and Proportion

Lecture - 4 hours per week per semester
Exercise - 2 hours per week per semester
Self organised studies - 150 hours

Teaching Materials and Literature

- Aubin, J.-P.: Applied Functional Analysis, Wiley, 2000, https://doi.org/10.1002/9781118032725
- Brezis, H.: Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer, 2011, https://doi.org/10.1007/978-0-387-70914-7
- Rudin, W.: Functional Analysis, McGraw Hill, 1991

Module Examination

Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination

Prerequisite:
- Successful completion of homework

Final module examination:
- Written examination, 90 min. **OR**
- Oral examination, 30 min. (with small number of participants)

In the first lecture it will introduced, if the examination will organized in written or oral form.

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

- Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Kombinatorik“
- Study programme Mathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend
- Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend
- Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“
- Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“
- Study programme Mathematics M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Combinatorics“
- Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“

If there is no need that the module is taught in English, alternatively the german version 11303 „Funktionalanalysis“ may beread instead.

Module Components

- Lecture: Functional Analysis
- Accompanying exercises
- Related examination

Components to be offered in the Current Semester	No assignment

Module 13849 Introduction to Computational Neuroscience

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13849	Compulsory elective

Modul Title	**Introduction to Computational Neuroscience** Einführung in Computational Neuroscience
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Glasauer, Stefan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon completion of the module, students are able to understandof neuronal systems and behavioral performance, to evaluate the analysis and modeling of neurons, as well as to implement and to analyse neurons and neural networks.
Contents	Based on examples the module presents the methodical procedure for the analysis and modeling of neurons and neural systems. Ethical aspects are discussed in connection with animal and human experiments. **Presented Topics:** Spiking neurons, resting membrane potential, ion channels, action potential, Hodgkin-Huxley model, phase plane analysis, leaky integrate-and-fire model, synaptic transmission, synaptic plasticity, firing rate neurons, neural networks, perceptron, Hebb's learning rule, attractor networks.
Recommended Prerequisites	Knowledge of the topics of the modules • 11112 *Mathematik IT-1 (Diskrete Mathematik)* • 11113 *Mathematik IT-2 (Lineare Algebra)* • 11213 *Mathematik IT-3 (Analysis)* • 11756 *Algorithmen und Datenstrukturen*, or 12101 *Algorithmieren und Programmieren*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	• P. Dayan, L. Abbott, Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems (2005), MIT Press, ISBN 978-0262541855 • Gerstner W, Kistler WM, Naud R, Paninski L: Neuronal Dynamics: From single neurons to networks and models of cognition, Cambridge University Press (2014), https://neuronaldynamics.epfl.ch
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of exercises **Final Module Examinatio:** • Written exam, 120 minutes **OR** • Oral examination, 30-45 minutes In the first lecture it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	100
Remarks	• Study programme Medizininformatik B.Sc.: Compulsory elective module in complex „Informatik" • Study programme Informatik B.Sc.: Compulsory elective module in complex „Praktische Informatik" (level 300) • Study programme Informations- und Medientechnik B.Sc.: Complex „Computer Science", compulsory elective module module in the field of study „Kognitive Systeme" • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Kognitions- und Neurowissenschaft“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications: Natural Sciences and Engineering“
Module Components	• Lecture: Introduction to Computational Neuroscience • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**140304** Examination Introduction to Computational Neuroscience

Module 13874 Introduction to Numerical Linear Algebra

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13874	Compulsory elective

Modul Title	**Introduction to Numerical Linear Algebra** Einführung in die Numerische Lineare Algebra
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Oevermann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful completion of the course the students know and understand classic and state of the art numerical methods and algorithms for solving linear systems of equations and to compute eigenvalues and eigenvectors. Through programming exercises they have acquired the practical skills to implement and validate numerical methods for scientific computing applications. The students have learned to use the programming language Python and common Python libraries/toolboxes (Numpy, Scipy) for an efficient and performant implementation methods used in scientific computing.
Contents	The module focuses on methods and algorithms suitable for solving linear sets of equations as they typically arise in many applications such as solving/discretzising partial differential equations in engineering sciences or machine learning algorithms. In particular we will cover: • Classic iterative methods for solving linear systems of equations (Jacobi, Gauß-Seidel, SOR) • Projection type methods for solving linear systems of equations (CG, GMRES) • Direct methods for sparse linear systems of equations • Jacobi eigenvalue algorithm, power iteration, QR iteration Additionally, we will address practical issues of solving large sparse systems of linear equations such as storage schemes and parallelisation strategies.

Recommended Prerequisites	Basic knowledge of mathematics as conveyed by mathematical courses in computer science or engineering from the first three to four semesters, e.g.: • Module 11101 *Lineare Algebra und analytische Geometrie I*, and • Module 11103 *Analysis I* or • Module 11112 *Mathematik IT-1 (Diskrete Mathematik)* • Module 11113 *Mathematik IT-2 (Lineare Algebra)* • Module 11213 *Mathematik IT-3 (Analysis)* or • Module *Höhere Mathematik - T1* • Module 11108 *Höhere Mathematik - T2* • Module 11206 *Höhere Mathematik - T3*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• G. H. Golub, C. F. van Loan: Matrix Computations • L. N. Trefethen, D. Bau: Numerical Linear Algebra, SIAM • Y. Saad: Iterative Methods for Sparse Linear Systems • T. A. Davis: Direct Methods for Sparse Linear Systems
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• three written examinations during the lecture or exercise period, 30 minutes each (1/3 each; 70% in total) • three programming tasks (1/3 each; 30% in total)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Numerics“ • Study programme Informatik B.Sc.: Compulsory elective module in complex „Mathematik“ or in field of application „Mathematik“ • Study programme Informatik M.Sc.: Compulsory elective module in complex „Mathematik“ or in field of application „Mathematik“ • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Numerics“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“

	Change from MAP to MCA. Registration for repitition of the MAP module only possible via Student Services.
Module Components	• Lecture: Introduction to Numerical Linear Algebra • Accompanying exercise
Components to be offered in the Current Semester	No assignment

Module 13911 Algebra: Structures and Algorithms

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13911	Compulsory elective

Modul Title	**Algebra: Structures and Algorithms** Algebra: Strukturen und Algorithmen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Averkov, Gennadiy
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students are able to work with basic algebraic concepts and know basic algebraic facts and constructions. They are able to use this knowledge to solve algebraic problems, with our without the assistance of computer-algebra systems. Students understand the basic algebraic algorithmic machinery of computational algebra.
Contents	• Commutative rings and ideals • Affine varieties • Groebner basis and the Hilbert basis theorem • Elimination of variables with Groebner bases and resultsants • Hilbert's Nullstellensatz • Selected applications (e.g. global optimization, solution of kinematic problems, automated theory proving)
Recommended Prerequisites	Knowledge of the content of the modules • 11101: *Lineare Algebra und analytische Geometrie I* or • 11112: *Mathematik IT-1 (Diskrete Mathematik)*, and • 11113: *Mathematik IT-2 (Lineare Algebra)*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• D. Cox, J. Little, and D. O'Shea: Ideals, Varieties, and Algorithms–An Introduction to Computational Algebraic Geometry and Commutative Algebra, Springer Publishing Company, 2010 • D. Cox, J. Little, and D. O'Shea: Using Algebraic Geometry, Springer Publishing Company, 2005 • S. Lang: Algebra, Springer Publishing Company, 2002
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	**Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30 - 45 min. (with small number of participants) In the first lecture it will introduced, if the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Kombinatorik“ • Studiengang Mathematics M.Sc.: Wahlpflichtmodul im Komplex „Analysis / Algebra / Combinatorics“ • Studiengang Mathematical Data Science M.Sc.: Wahlpflichtmodul im Komplex „Advanced Mathematical Methods in Data Science“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ • Study programme Informatik B.Sc.: Compulsory elective module in „Praktische Mathematik" or in field of application „Mathematics" • Study programme Informatik M.Sc.: Compulsory elective module in „Mathematik" or in field of application „Mathematik" • Study programme Cyber Security M.Sc.: Compulsory elective module in complex „Computer Science“
Module Components	• Lecture *Algebra: Structures and Algorithms*, with integrated exercise • Related examination
Components to be offered in the Current Semester	**130250** Examination Algebra: Structures and Algorithms --. Reexamination

Module 13969 Introduction to Cyber Security

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13969	Compulsory elective

Modul Title	**Introduction to Cyber Security** Einführung in die IT-Sicherheit
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. Panchenko, Andriy
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students will • have Basic knowledge of IT security, • now the technical terms to understand current publications and relevant system solutions, • be able to independently familiarise themselves with advanced IT security concepts and to acquire futher skills.
Contents	Introductory definition of technical terms; protection objectives; security risks and threats; Malware; Attack techniques; security functions and services; Access control; basic cryptographic functions: symmetric crypto systems (stream and block ciphers, DES, AES)h public key cryptography (RSA, El-Gamal, ECC), Subject and object authentication (cryptographic hash values, message authentication codes), digital signatures, key management; cryptographic protocols (Diffie-Hellmann, Kerberos, Needham-Schröder, and others); protection of IT infrastructures, firewalls, intrusion detection; honeypots;
Recommended Prerequisites	none
Mandatory Prerequisites	No successful participation in module *11889 - Introduction to Cyber Security*.
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 90 hours

Teaching Materials and Literature	• Stallings: Cryptography and Network Security: Principles and Practice, Pearson • Paar, Pelzl: Understanding Cryptography: A Textbook for Students and Practitioners, Springer
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	**Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be anounced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanded Methods“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications: Computer Science & Artificial Intelligence“ The module is not approved for the study programmes Cyber Security M.Sc. and Computer Science M.Sc.
Module Components	• Lecture: Introduction into Cyber Security • Accompanying exercise • Related examination
Components to be offered in the Current Semester	No assignment

Module 14015 Introduction to Mathematical Methods in Artificial Intelligence

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14015	Compulsory elective

Modul Title	**Introduction to Mathematical Methods in Artificial Intelligence** Einführung in mathematische Methoden der künstlichen Intelligenz
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Breuß, Michael Prof. Dr. rer. nat. habil. Hauer, Daniel
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will be acquainted with basic principles and main techniques of mathematical methods that are useful in artificial intelligence and machine learning. They understand the inner workings of the techniques. They are able to apply the presented methods.
Contents	In the lectures the theory and methods are presented. The knowledge about the material is deepened in self-organised studies and practized in the tutorial at hand of homework problems. Major topics are: • important concepts in linear algebra and algebra • analytic geometry, e.g. projection mappings • linear regression • matrix factorization, e.g. Cholesky decomposition • basics of optimization, e.g. in gradient descent • probability and distributions, e.g. Bayes' theorem, stochastic gradient descent • dimensionality reduction, e.g. by principal component analysis, singular value decomposition • selected applications in artificial intelligence
Recommended Prerequisites	Knowledge of calculus and linear algebra, e.g. knowledge of the content of the modules • 11113 *Mathematik IT-2 (Lineare Algebra)* • 11213 *Mathematik IT-3 (Analysis)*

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• „Mathematics for Machine Learning“, Deisenroth, Faisal, Ong, Cambridge University Press, (2020)
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Written test 1, 30 minutes (weighting: 1/3) • Written test 2, 30 minutes (weighting: 1/3) • Written test 3, 30 minutes (weighting: 1/3)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanced Methods“
Module Components	• Lecture: Introduction to Mathematical Methods in Artificial Intelligence • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**130360** Lecture/Exercise Introduction to Mathematical Methods in Artificial Intelligence - 4 Hours per Term **130361** Examination Introduction to Mathematical Methods in Artificial Intelligence

Module 14034 Languages of Artificial Intelligence

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14034	Compulsory elective

Modul Title	**Languages of Artificial Intelligence** Sprachen der Künstlichen Intelligenz
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Hofstedt, Petra
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successful completion of the module, students have a theoretically sound overview of selected programming paradigms in the AI context. They know concrete languages of these paradigms, their procedures for evaluation and typical applications. They are familiar with practical and methodological aspects in the application of AI methods and algorithms using different programming languages.
Contents	The course includes as topics, among others, languages and concrete AI applications for a number of paradigms, respectively, e.g.: • logical programming • functional programming • object-oriented programming • constraint-based programming • extensions of the above paradigms, if applicable
Recommended Prerequisites	• Solid programming knowledge in at least one common programming language (Java, C++, C#, Haskell, Python, etc.)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• S. Russell, P. Norvig: Artificial Intelligence. A Modern Approach. Pearson. 2021.

- F. Rabhi, G. Lapalme: Algorithms. A Functional Programming Approach. Peason. 2006.
- U. Nilsson, J. Maluszynski: Logic, Programming, and Prolog. Wiley & Sons. 1995.
- K. Apt: Principles of Constraint Programming. Cambridge University Press. 2010.
- F. Baader, T. Nipkow: Term Rewriting and All That. Cambridge University Press. 1999.
- E. Shalom: A Review of Programming Paradigms Throughout the History. 2015.

Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of one prerequisite test (90 min.) in the first week of the semester to ensure basic programming skills **Final module examination:** • Written examination, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex „Praktische Informatik“ (level 400) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanced Methods" • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme“ • Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Anwendungen“, field „Informatik“
Module Components	• Lecture Languages of Artificial Intelligence • Accompanying exercises • Related examination
Components to be offered in the Current Semester	**120742** Examination Languages of Artificial Intelligence Reexamination

Module 14060 Research Module in Artificial Intelligence

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14060	Compulsory elective

Modul Title	**Research Module in Artificial Intelligence** Forschungsmodul in Künstlicher Intelligenz
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successfully completing the module, students have the ability to familiarize themselves with the a targeted application or research-related field. They have improved their research organization and their writing skills as beginning researchers. They can participte in a technical discussion within the context of international science and present their result in written and oral form. In addition, they have acquired individual skills such as diligence, perseverance, time management and initiative.
Contents	The module consists of a study project conaining a project planning phase as well as a laboratory phase. At the end of the module the project is presented by a lecture and aresearch-report. The project is usually carried out in the same subject area in which the master's thesis is to bewritten. Under the guidance of a supervisor - normally the students` mentor, the students deal with a scientific question (also from an ethical and social point of view) in this field.
Recommended Prerequisites	none
Mandatory Prerequisites	• At least 54 credit points in mandatory electives from the program catalog
Forms of Teaching and Proportion	Seminar - 1 hours per week per semester Consultation - 1 hours per week per semester Study project - 150 hours

Teaching Materials and Literature	Depending on the project, literature will be provided by the supervisor at the beginning of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Interim report on the project planning phase, 8-10 pages, 20 % • Final presentation of the project, 30 Minutes, 30 % • research-report of the project, 20-25 pages, 50 %
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Advanced Methods“
Module Components	• Seminar/Consultation Research Module in Artificial Intelligenc - - 2 Hours per Week per Semester Selection from one of the offered seminars
Components to be offered in the Current Semester	**100050** Seminar Research Module in Artificial Intelligence - 2 Hours per Term **120930** Seminar Research Module in Artificial Intelligence - 2 Hours per Term **130320** Seminar Research Topics in Artificial Intelligence and Computer Vision - 2 Hours per Term **142140** Seminar Projektmodul - 2 Hours per Term

Module 14336 Introduction to Bioinformatics

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14336	Compulsory elective

Modul Title	**Introduction to Bioinformatics** Einführung in die Bioinformatik
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students have acquired an overview of the fundamentals of bioinformatics. This includes an introduction to relevant molecular processes, scientific instruments to investigate these processes, and the data generated by them. For central computational problems, students are able to discuss advantages and disadvantages of statistical and basic algorithmic approaches, respectively adapt them to specific biological questions. Students are able to analyze specific biological data using appropriate software libraries for Python.
Contents	The focus will be on the basics of the following areas: • An introduction to molecular biology including relevant scientific instruments and the Omics-data generated by them. • Pair-wise and multiple sequence alignments, seed-and-extend approaches, and genome indexes • Evolutionary models and phylogenetic trees • Signals in sequences: identification of motifs • Assembly of genomes and transcriptomes • Gene expression analysist
Recommended Prerequisites	Good knowledge of discrete probability, algorithms and data structures at the undergraduate level. Advanced knowledge of programming in Python and the Linux command line.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester

	Study project - 30 hours Self organised studies - 90 hours
Teaching Materials and Literature	• Biological Sequence Analysis. Durbin, Eddy, Krogh, Mitchison (1998) • Statistical Methods in Bioinformatics. Ewens and Grant (2005) • Review and Original Research Articles
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 min. OR • Oral examination, 30-45 min. The examination format will be announced during the first lecture.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex „Praktische Informatik“
Module Components	• Lecture: Introduction to Bioinformatics • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**100072** Examination Introduction to Bioinformatics

Module 14493 AI-Assisted Statistics: Exploring Data with ChatGPT & Co

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14493	Compulsory elective

Modul Title	**AI-Assisted Statistics: Exploring Data with ChatGPT & Co** KI-unterstützte Statistik: Datenanalyse mit ChatGPT & Co
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. Urbig, Diemo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completing the course, students will be able to apply statistical concepts and methods to analyze real-world data effectively. They have the skills needed to conduct a simple empirical research project from start to finish, including defining a research question, collecting and analyzing secondary data, and presenting their findings. By integrating AI tools such as ChatGPT throughout the research process, students know how to enhance their efficiency and creativity in the process of hypothesis development, data analysis, and data interpretation. The course will also foster critical thinking, enabling students to reflect on the opportunities and limitations of using AI in research, as well as the ethical implications. Furthermore, students will develop their ability to communicate research findings effectively in both academic and non-academic contexts while improving their collaboration and problem-solving skills in team-based environments.
Contents	The course *Statistics with ChatGPT & Co.* introduces students to the principles and practices of using AI-driven tools specifically gneeral purpose large language models (LLM), such as ChatGPT in the context of data analysis. IN groups, students will explore the research process, starting with identifying a research question and locating suitable secondary data sources online or in databases. The course provides hands-on training in statistical analysis, including descriptive statistics, regression techniques, and data visualization, with the aid of AI tools like ChatGPT to support each phase. Students will engage in reflective discussions about their experiences with AI in research, examining both its potential and its limitations. The centerpiece of the course is the development and execution of an independent research project, where

	students will collect, analyze, and interpret secondary data to address their chosen research question. Group work of up to thre epeople is possible. Alongside these activities, the course emphasizes the ethical and practical challenges of using AI in research, culminating in the presentation of findings in written and oral formats.
Recommended Prerequisites	Basics in statistics, in particular simple regression analyses
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Han, J., Qiu, W., & Lichtfouse, E. (2024). ChatGPT in Scientific Research and Writing: A Beginner's Guide. In ChatGPT in Scientific Research and Writing: A Beginner's Guide (pp. 1-109). Cham: Springer Nature Switzerland
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Two-weakly progress and reflection reports of at most 1 page, group-based (20%) • Final presentation, 15 min, group-based (10%) • Term paper, 15 pages, individual submission and grading (70%) *The presentation and the progress and reflection reports are done in working groups if projects have been worked on in working groups, for the term paper individual papers are handed in and graded individually - however, overlaps in the texts of members of the same group are allowed when group members are declared on the title page of the term paper. Groups are up to 3 members.*
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!*** ***No offer in summer semester 2026.***
Module Components	Seminar
Components to be offered in the Current Semester	No assignment

Module 14495 Optimization in Business Transformation

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14495	Compulsory elective

Modul Title	**Optimization in Business Transformation** Optimierung der Unternehmensumwandlung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. Xie, Lin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	By the end of this course, students will be able to: 1. **Understand Optimization Concepts** 2. **Formulate and Solve Optimization Problems** 3. **Apply Optimization to Business Scenarios** 4. **Utilize Optimization Tools and Software** 5. **Develop Critical Thinking and Analytical Skills** 6. **Connect Optimization with Business Transformation Goals**
Contents	• Foundations of Optimization in Business • Linear Optimization Techniques • Integer Programming • Network Optimization • Standort- und Tourenplanung • Business Applications and Transformation
Recommended Prerequisites	• basic mathematical knowledge is desired, such as the content of Module 11112 *Mathematik IT-1*
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Winston W. L. Operations Research: Applications and Algorithms, fourth edition, Thomson, 2004 Further materials are provided via Moodle (including lecture slides and additional materials including videos, readings etc.)

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written Test, 90 minutes Bonus points (10 % of total points) can be earned through the group assignment and will be added to your final score **only if you pass the written test.**
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	150
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!***
Module Components	Lecture and Excercise
Components to be offered in the Current Semester	**531001** Lecture Optimization in Business Transformation - 2 Hours per Term **531002** Exercise Optimization in Business Transformation - 2 Hours per Term **531003** Examination Optimization in Business Transformation

Module 14726 Mathematical Optimization Techniques and Applications

assign to: Advanced Methods

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14726	Compulsory elective

Modul Title	**Mathematical Optimization Techniques and Applications** Mathematische Optimierungstechniken und Anwendungen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fügenschuh, Armin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon successful completion of the module, students will have acquired an understanding of core mathematical tools used in modern optimization. They will be able to identify optimization structures in real-world problems, formalize these problems in mathematical terms, and apply suitable algorithms to obtain and interpret solutions.
Contents	Foundations of optimization theory, global vs. local optimality, geometry of optimization, optimization for graph problems, fundamentals of linear programming, duality principles, advanced simplex methods, discrete optimization, interior point and ellipsoid methods, nonlinear optimization, applied modeling. Emphasis is placed both on theoretical insights and algorithmic implementation.
Recommended Prerequisites	Knowledge of subject matters of the modules • 11103: Analysis I • 11104: Analysis II • 11101: Lineare Algebra und analytische Geometrie I or of the modules • 11112: Mathematik IT-1 (Diskrete Mathematik) • 11113: Mathematik IT-2 (Lineare Algebra) • 11213: Mathematik IT-3 (Analysis)
Mandatory Prerequisites	• No successful participation in module 13862 Optimierung und Operations Research.

Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• V. Chvatal, Linear Programming, Bedford St Martins Pr 3PL, 2016 • R.J. Vanderbei: Linear Programming - Foundations and Extensions, 5th Edition, Springer, 2020
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 intermediate tests of 30 minutes each, written during the lecture period. The best 3 count 1/3 each for the final grade.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Optimierung" • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Optimization" • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science" • Study programme Artificial Intelligence Science M.Sc.: Compulsory elective module in complex „Advanced Methods" • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme" • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject"
Module Components	• Lecture: Optimization and Operations Research • Accompanying exercise
Components to be offered in the Current Semester	No assignment

Module 11881 Foundations of Data Mining

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	11881	Compulsory elective

Modul Title	**Foundations of Data Mining** Grundlagen des Data Mining
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Schmitt, Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Acquaintance with the statistical and learning-theoretical foundations of knowledge extraction from large data sets; knowledge of specific notions and of mathematical background in order to understand current publications and software concerning the field; ability of transfer to concrete problems; knowledge of algorithms and their usage.
Contents	• Foundation of statistics • Clustering (partition-based, density-based, hierarchical, ...) • Classification (decision trees, support vector machines, deep learning on convolution neural networks, ...) • Association rules (frequent itemsets) • further data mining approaches Acquired knowledge will be applied within a project.
Recommended Prerequisites	The module cannot be successfully completed without knowledge of the content of • 11112 *Mathematik IT-1 (Diskrete Mathematik)* • 11113 *Mathematik IT-2 (Lineare Algebra)*
Mandatory Prerequisites	• No successful participation in module 12351 *Grundlagen des Data Mining*.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• James, Gareth; Witten, Daniela; Hastie, Trevor; Tibshirani, Robert: An Introduction to Statistical Learning with Applications in R. Springer, New York 2013. • Aloaydin, Ethem: Machine Learning. The MIT Press, Massachusetts Institute of Technology, 2004. • Mitchell, Tom M.: Machine Learning. McGraw-Hill, 1997.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of practical training tasks and exercises tasks **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be annunced, if the examination will offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	80
Remarks	• Study programme Informatik B.Sc.: Compulsory elective module in complex „Grundlagen der Informatik“ (level 300) • Study programme eBusiness M.Sc.: Compulsory elective module in main focus „Entwicklung und Aufbau von eBusiness-Systemen" • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Cyber Security M.Sc.: Compulsory elective module in complex „Computer Science“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Anwendungen“, field „Informatik“ • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Anwendungen“, field „Informatik“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“ If there is no need that the module is taught in English, alternatively the german version 12351 „Grundlagen des Data Mining“ may be offered instead. Module 11881 „Foundations of Data Mining“ and 12351 „Grundlagen des Data Mining“ can not be combined.
Module Components	• Lecture Foundations of Data Mining • Accompanying exercise with laboratory • Related examination
Components to be offered in the Current Semester	**120285** Examination Grundlagen des Data Mining / Foundations of Data Mining

Module 13500 Introduction to Neural Signal Analysis

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13500	Compulsory elective

Modul Title	**Introduction to Neural Signal Analysis** Einführung in die neuronale Signalanalyse
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Glasauer, Stefan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will demonstrate a comprehensive understanding of neural signaling and EEG signal acquisition. They will possess the ability to apply basic time and frequency domain analyses for processing EEG signals.
Contents	• Introduction to Neural Signaling • EEG Signal Acquisition • Artifacts and preprocessing techniques • Time Domain Analysis • Evoked potentials • Frequency Domain and EEG signals spectral analysis • Applications in Computational Neuroscience • Ethical aspects of brain wave measurements
Recommended Prerequisites	Knowledge of the topics of the modules • 11112 Mathematik IT-1 (Diskrete Mathematik) • 11113 Mathematik IT-2 (Lineare Algebra) • 11213 Mathematik IT-3 (Analysis) • 11756 Algorithmen und Datenstrukturen
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Biomedical Signal Analysis (IEEE Press Series on Biomedical Engineering), Rangaraj M. Rangayyan, Wiley-IEEE Press, ISBN:9780470911396
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of homework **Final Module Examinatio:** • Written exam, 120 minutes **OR** • Oral examination, 30-45 minutes In the first lecture it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	100
Remarks	• Study programme Medizininformatik B.Sc.: Compulsory elective module in complex „Medizininformatik" • Study programme Informations- und Medientechnik B. Sc.: Complex „Informatik", compulsory elective module module in the field of study „Kognitive Systeme" • Study programme Informatik B.Sc.: Compulsory elective module in complex „Praktische Informatik" (level 300) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“
Module Components	• Lecture: Introduction to neural signal analysis • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**140340** Lecture Introduction to neural signal analysis - 2 Hours per Term **140341** Exercise Introduction to neural signal analysis - 2 Hours per Term **140344** Examination Introduction to neural signal analysis

Module 13593 Applied Algebraic Quantum Theory

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13593	Compulsory elective

Modul Title	**Applied Algebraic Quantum Theory** Angewandte algebraische Quantentheorie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Wolff, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will have a in-depth knowledge of algebraic quantum theory. They know its application in different areas. They can assess the importance of algebraic quantum theory in the context of artificial intelligence.
Contents	Algebraic quantum theory, i.e. the theory of operator algebras and their representations is an important branch of modern functional analysis, connecting non-commutative algebra with topology, measure theory and lattice theory. In the past, many applications in statistical mechanics and quantum field theory have been developed. Yet most recently, algebraic quantum theory appears as a powerful framework for artificial intelligence and cognitive dynamical systems as well. The lecture elucidates the basic concepts of algebraic quantum theory, such as observable algebras, representation theory, and contextual emergence in the light of present and future applications. **Outline** 1. The ideas of pioneer quantum theory as motivation: Systems, state preparation, measurement, dynamics. Operator algebras on Hilbert space. 2. Coordinate-free (Dirac) and representation-free (von Neumann) descriptions: C*-algebras, W*-algebras, GNS-construction and representation theory. 3. Classical dynamical systems: symbolic dynamics, neural automata and vector symbolic architectures. 4. Contextual emergence: context states, weak topologies, singular perturbations, emergent descriptions.

5. Projector lattices: ontology inference for cognitive dynamical systems.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Self organised studies - 150 hours

Teaching Materials and Literature

- Primas, H. (1981). Chemistry, Quantum Mechanics and Reductionism. Lecture Notes in Chemistry. Springer, Berlin.
- Haag, R. (1992). Local Quantum Physics: Fields, Particles, Algebras. Texts and Monographs in Physics. Springer, Berlin.
- Sakai, S. (1971). C*-Algebras and W*-Algebras. Ergebnisse der Mathematik und ihrer Grenzgebiete. Springer, Berlin.
- beim Graben, P. & Atmanspacher, H. (2006). Complementarity in classical dynamical systems. Foundations of Physics, 36, 291 – 306.
- beim Graben, P.; Barrett, A. & Atmanspacher, H. (2009). Stability criteria for the contextual emergence of macrostates in neural networks. Network: Computation in Neural Systems, 20, 178 – 196.
- Carmantini, G. S.; beim Graben, P.; Desroches, M. & Rodrigues, S. (2017). A modular architecture for transparent computation in recurrent neural networks. Neural Networks, 85, 85 – 105.
- beim Graben, P.; Huber, M.; Meyer, W.; Römer, R. & Wolff, M. (2021). Vector symbolic architectures for context-free grammars. Cognitive Computation, 10.1007/s12559-021-09974-y.
- Huber-Liebl, M.; Römer, R.; Wirsching, G.; Schmitt, I.; beim Graben, P. & Wolff, M. (subm.). Quantum-inspired cognitive agents. Frontiers in Applied Mathematics and Statistics.

Module Examination

Final Module Examination (MAP)

Assessment Mode for Module Examination

- Written examination, 120 min. **OR**
- Oral examination, 30-40 min. (with small number of participants)

In the first lecture it will introduced, if the examination will organized in written or oral form.

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

- Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“
- Study programme Artificial Intelligence Engineering M.Sc.: Compulsory elective module in complex „Cognitive Science and Neuroscience“
- Study programme Computer Science M.Sc.: Compulsory elective module in „Mathematics“ or in field of application „Mathematics“
- Study programme Applied Mathematics M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Combinatorics“

	The module is offered as a block course.
Module Components	• Lecture: Applied Algebraic Quantum Theory • Related examination
Components to be offered in the Current Semester	No assignment

Module 13813 Logic in Databases

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13813	Compulsory elective

Modul Title	**Logic in Databases** Logik in Datenbanken
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Schmitt, Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	After successfully completing the module, students will will be able expressions of different kinds of logic for data modeling and querying as well as for information extraction.
Contents	Predicate logic, Herbrand model, datalog, fuzzy logic, quantum mechanics and logic, query language CQQL, probabilistic databases, algorithms for evaluating logical expressions.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Foundations of Databases“, Abiteboul, Hull, Vianu, Addison Wesley, 1996 • „Multimedia-Kurs Datenbanksysteme“, Werner Kießling, Springer-Verlag, 1998 • „Quantenlogik für Ingenieure und Informatiker“, Günther Wirsching, Ingo Schmitt, Matthias Wolff, Springer-Verlag • Script
Module Examination	Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of practical training tasks and exercise tasks **Final module examination:** • Written examination, 90 min. OR • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will announced, wheter the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	80
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex "Grundlagen der Informatik" (level 400) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“
Module Components	• Lecture: Logic in Databases • Accompanying exercise • Accompanying laboratory • Related examination
Components to be offered in the Current Semester	**120275** Examination Logic in Databases

Module 13838 Information Retrieval

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13838	Compulsory elective

Modul Title	**Information Retrieval** Information Retrieval
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Schmitt, Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know about problems, models and methods of information retrieval. This includes understanding the concepts of search engines and implementation with their advantages and disadvantages.
Contents	The goal of information retrieval is the search for text documents. With the growth of the internet this goal gained much importance. The course introduces several information retrieval models and algorithms. Furthermore, concepts of how to evaluate retrieval results will be discussed. The content of the course is: • Motivation and introduction to the search of textual documents • Evaluation of IR systems • Vagueness in languages • Simple IR models and their implementations • Vector Space Model • Format of document management • Alternatives to global search • Search engines in WWW Acquired knowledge will be applied within a project.
Recommended Prerequisites	The module cannot be successfully completed without knowledge of the content of • 12330 *Datenbanken*
Mandatory Prerequisites	No successful participation in module 14460 Information Retrieval.

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Laboratory training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• "Information Retrieval", van Rijsbergen (as HTML on the Web) • "Information Retrieval 1: Grundlagen, Modelle und Anwendungen", Andreas Henrich (as PDF on the Web)
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • successful completion in practical training tasks and in exercises tasks **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will announced, whether the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	80
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Acquisition, Representation, and Processing“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“
Module Components	• Lecture: Information Retrieval • Accompanying exercises (with integrated laboratory) • Related examination
Components to be offered in the Current Semester	**120260** Lecture Information Retrieval - 2 Hours per Term **120261** Exercise/Practical training Information Retrieval - 2 Hours per Term **120278** Examination Information Retrieval

Module 13839 Advanced Database Models

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13839	Compulsory elective

Modul Title	**Advanced Database Models** Erweiterte Datenbankmodelle
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Schmitt, Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	Students understand • SQL:2003, • object-relational and object-oriented database model, • XML-queries, • spatial data and queries.
Contents	For special applications from the areas of manufacturing and science classical relational database modelling basing on table structures is not adequate. Alternatively, several new database models and technologies were developed. The course covers SQL:2003, ODMG and XML. Focus is on data modelling and query techniques as well as implementation of behaviour in form of methods. Further focus is on spatial data and queries for geographical information systems. Acquired knowledge will be applied within a project.
Recommended Prerequisites	The module cannot be successfully completed without knowledge of the content of • 12330: Datenbanken
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Laboratory training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• "SQL:1999 & SQL:2003" von Can Türker, dpunkt.verlag, 2003

	• "Objektrelationale Datenbanken: Ein Lehrbuch" von Can Türker und Gunter Saake, Punkt.verlag 2006
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • successful completion in practical training tasks and in exercises tasks **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will announced, whether the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	80
Remarks	• Study programme Informatik B.Sc.: Compulsory elective module in complex "Praktische Informatik" (level 300). • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex “Software-basierte Systeme“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“
Module Components	• Lecture: Advanced Data Models • Accompanying exercises (with integrated laboratory) • Related examination
Components to be offered in the Current Semester	No assignment

Module 13840 Data Warehouses

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13840	Compulsory elective

Modul Title	**Data Warehouses** Data-Warehouse-Technologien
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Schmitt, Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students will have acquired knowledge and capability to design, model, and to optimize a data warehouse.
Contents	Data is frequently stored redundantly and is distributed over several data sources in an enterprise. Data quality is usually low. Analyzing data should be made possible. The course gives an introduction into the architecture and processes of data warehouse systems. Focus is on database aspects including design, modelling, ETL-processes, querying and optimization. Acquired knowledge will be applied within a project. This module builds on existing database knowledge. In particular, expertise in SQL, normalization theory and database design is needed.
Recommended Prerequisites	The module cannot be successfully completed without knowledge of the content of • 12330 *Datenbanken*
Mandatory Prerequisites	No successful participation in module 14459 Data-Warehouse-Technologien.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Laboratory training - 1 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• A. Bauer, H. Günzel: "Data Warehouse Systeme -- Architektur, Entwicklung, Anwendung": 3. Auflage, dpunkt.verlag, Heidelberg, 2009 • W. Lehner: "Datenbanktechnologie für Data-Warehouse-Systeme": dpunkt.verlag, Heidelberg, 2003 • W.H. Inmon: "Building the Data Warehouse": Wiley & Sons, New York, 1996 • G. Saake, A. Heuer, K. Sattler: "Datenbanken: Implementierungstechniken": 2. Auflage, mitp-Verlag, Bonn, 2005 • R. Kimball, L. Reeves, M. Ross, W. Thornthwaite: The Data Warehouse Lifecycle Toolkit": Wiley & Sons, New York, 1998
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • successful completion in practical training tasks and in exercises tasks **Final module examination:** • Written examination, 120 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will introduced, if the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	80
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“
Module Components	• Lecture: Data Warehouses • Accompanying exercises (with integrated laboratory) • Related examination
Components to be offered in the Current Semester	**120210** Lecture Data Warehouses / Data-Warehouse-Technologien - 2 Hours per Term **120211** Exercise/Practical training Data Warehouses / Data-Warehouse-Technologien - 2 Hours per Term **120274** Examination Data Warehouses / Data-Warehouse-Technologien

Module 13841 Speech Processing

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13841	Compulsory elective

Modul Title	**Speech Processing** Sprachverarbeitung
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Wolff, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students are able to understand the principles of human speech production and perception and the basic principles of technical speech synthesis, speech recognition and natural language understanding.
Contents	Speech and language, phonetics and phonology (phonologic classification), linguistics, articulatory phonetics (physiology of speech production, model based electronic speech production), auditory phonetics (physiology and psychology of speech perception, speech signal analysis), speech quality assessment (auditory and instrumental methods)
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Slide manuscript • Literature will be recommended in the first lecture
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:**

	• Successful completion of laboratory experiments as part of the practical training **Final module examination:** • Written examination, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Informations- und Medientechnik B.Sc., PO 2017: Compulsory elective module in complex: "Medientechnik und Medienwissenschaften", all fields of study • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Hardware-basierte Systeme: Elektrotechnik, Informationstechnik und Sensorik“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications: Computer Science & Artificial Intelligence“
Module Components	• Lecture: Speech Processing • Accompanying exercise • Related examination
Components to be offered in the Current Semester	No assignment

Module 13842 Virtual Reality and Agents

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13842	Compulsory elective

Modul Title	**Virtual Reality and Agents** Virtual Reality und Agenten
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students have acquired knowledge of approaches, trends and applications of virtual and mixed environments (virtual and mixed reality). Among other things, they are familiar with tracking, display systems, interaction, input options, scene graphs and collision detection.
Contents	The course focuses on a particular form of Human-Computer Interaction: virtual environments and embodied virtual agents. With the help of tracking and advanced computer graphics, users can be embedded in a virtual environment and allowed to interact with it. Specific topics that will be covered include registration and tracking, perception and Virtual Reality, Display and input systems, interaction techniques, scene graphs, rendering for virtual and mixed environments, collision detection, complete virtual reality systems, applications, knowledge of approaches, trends and applications of virtual and mixed environments (virtual and mixed reality) as well as of embodied virtual agents.
Recommended Prerequisites	Knowledge of the content of module • 12311 *Grundzüge der Computergrafik*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Practical training - 2 hours per week per semester Study project - 1 hours per week per semester

	Self organised studies - 75 hours
Teaching Materials and Literature	• Doug Bowman, et al.: 3D User Interfaces. Theory and Practice, Addison Wesley, 2004 • Grigore Burdea, Philippe Coiffet: Virtual Reality Technology, 2. Auflage, Wiley & Son, 2003 • William Sherman, Alain Craig: Understanding Virtual Reality. Interfaces, Applications and Design, Morgan Kaufman, 2002 • Roy Kalawsky: The Science of Virtual Reality and Virtual Environments, Addison-Wesley, 1993 Suggestions for further literature can be found on the department's website.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 min. **OR** • Oral examination, 30-40 min. (with small number of participants) In the first lecture it will be announced, wheter the examination will be organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	100
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex „Praktische Informatik“(level 400) • Study programme Informations- und Medientechnik B.Sc.: Compulsory elective module in complex: „Informatik“, all fields of study • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“
Module Components	• Lecture: Virtual Reality and Agents • Accompanying exercises • Accompanying laboratory • Related examination
Components to be offered in the Current Semester	**120990** Examination Virtual Reality and Agents

Module 13845 Multimedia Retrieval

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13845	Compulsory elective

Modul Title	**Multimedia Retrieval** Retrieval in Multimedia-Datenbanken
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Schmitt, Ingo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will have in-depth knowledge of how retrieval systems work for searching multimedia databases and will be able to apply them practically.
Contents	Introduction and terms, principles of information retrieval, multimedia information retrieval, feature transformation, distance functions, search algorithms, index structures, query languages. Acquired knowledge will be applied within a project.
Recommended Prerequisites	The module cannot be successfully completed without knowledge of the content of • 12330 *Datenbanken*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• "Ähnlichkeitssuche in Multimedia-Datenbanken: Retrieval, Suchalgorithmen und Anfragenbehandlung", Ingo Schmitt, Oldenbourg Wissenschaftsverlag, 2005
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of practical training tasks and exercise tasks

	Final module examination: • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will introduced, if the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	80
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex "Praktische Informatik" (level 400) • Study programme Informations- und Medientechnik M.Sc.: Compulsory elective module in "Multimedia-Systeme" • Study programme Künstliche Intelligenz Technologie B.Sc.: Compulsory elective module in complex „Software-basierte Systeme“
Module Components	• Lecture: Multimedia Retrieval • Accompanying exercise • Related examination
Components to be offered in the Current Semester	No assignment

Module 13889 Stochastic Processes

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13889	Compulsory elective

Modul Title	**Stochastic Processes** Stochastische Prozesse
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Wunderlich, Ralf Prof. Dr. rer. nat. Hartmann, Carsten
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Each summer semester odd year
Credits	8
Learning Outcome	After successfully completing the module, students • are familiar with the basic concepts and ideas behind random processes, • know models and methods for time-dependent random phenomena, • are prepared for studying advanced topics in stochastics • have experience in autonomously doing research based on specific applications.
Contents	• Markov processes, discrete and continuous in time, • communication classes and asymptotic behaviour of Markov chains • processes with independent and stationary increments, martingales • stopping times and stopping theorems, optimal stopping • applications from finance, science and engineering
Recommended Prerequisites	Knowledge of the contents of module • 11217 Wahrscheinlichkeitstheorie
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Self organised studies - 180 hours
Teaching Materials and Literature	• P. Bremaud. Markov Chains, Springer, 1999. • K.L Chung. Markov Chains: With Stationary Transition Probabilities. Springer, 2012. • J.L. Doob: Stochastic Processes. Wiley, 1990.

- R. Durrett. Essentials of Stochastic Processes. Springer, 1999.
- S.R.S. Varadhan. Stochastic Processes. AMS, 2007.

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 90 min. **OR** • Oral examination, 30 min. In the first lecture it will be anounced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in the complex „Stochastik“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Informatik B.Sc.: Compulsory elective module in field of application „Mathematik“ • Study programme Informatik M.Sc.: Compulsory elective module in field of application „Mathematik“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Stochastics“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science“
Module Components	• Lecture: Stochastic Processes • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**130892** Examination Stochastic Processes (Wiederholung)

Module 13908 Experimental Techniques in Physics Supported with Artificial Intelligence / Machine Learning

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13908	Compulsory elective

Modul Title	**Experimental Techniques in Physics Supported with Artificial Intelligence / Machine Learning** Experimentelle Techniken in der Physik gestützt durch Künstliche Intelligenz / Maschinelles Lernen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. hab. Jablonski, Ireneusz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After completion of the module, students will have an overview on methods and tools used for experimentation with physical systems. They know the role of artificial intelligence/machine learning (AI/ML) in inference with experimental data processing. They are able to apply the acquired knowledge in computer experiments realized during laboratories.
Contents	The subject of the module is the fundamentals of experiment design, including the theoretical and practical aspects of experiment planning and execution. This includes, for example, the role of observation and measurement in cognition process, data collection and processing with the use of statistical and AI/ML methods, data and system modeling, computer simulation, and planning of experiment. The laboratory will use computer simulation to solve selected problems of experimentation, e.g. forward and inverse modeling, signal reconstruction, model identification, experiment planning. Statistical and AI/ML techniques will be used in exemplary tasks. The form of the class includes the realization of tasks under supervision and solving self-defined problems.
Recommended Prerequisites	• Knowledge of mathematics, especially statistics
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Brandt S.: Data analysis. Statistical and computational methods for scientists and engineers. 4th Ed., Springer, Heidelberg 2014 • Söderstöm T., Stoica P.: System identification. Prentice Hall, Michigan, USA, 1989 • Lakshmanan V., Robinson S., Munn M.: Machine learning design patterns. Solutions to common challenges in data preparation, model building, and MLOps. O'Reilly, USA 2020
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of the project task, 30 h **Final module examination:** • Written examination, 90 min. OR • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be announced, wheter the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“
Module Components	• Lecture: Data exploration and system management using AI/ML • Accompanying laboratoy • Related examination
Components to be offered in the Current Semester	**152250** Lecture Experimental techniques in physics supported with AI/ML - 2 Hours per Term **152251** Practical training Experimental techniques in physics supported with AI/ML - 2 Hours per Term **152252** Examination Experimental techniques in physics supported with AI/ML

Module 13912 Coding Theory

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13912	Compulsory elective

Modul Title	**Coding Theory** Datenkodierung
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Averkov, Gennadiy
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will know and understand the problems and basics of data coding. They can transfer known facts and procedures of linear algebra to this application field and have learned further concepts of algebra. They know linear codes and understand the meaning of the parameters. They know simple decoding algorithms, can apply them and show their correctness.
Contents	• Basics of coding theory • Theory of linear codes • Examples of linear codes, in particular, Reed-Solomon codes • General and specific decoding algorithms • Simple Goppa codes
Recommended Prerequisites	Knowledge of the content of the modules • 11101: *Lineare Algebra und analytische Geometrie I* or • 11112: *Mathematik IT-1 (Diskrete Mathematik)*, and • 11113: *Mathematik IT-2 (Lineare Algebra)*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• van Lint, J., van der Geer, G., Introduction to Coding Theory and Algebraic Geometry

	• J.I. Hall, Notes on Coding Theory • Willems, Wolfgang, Codierungstheorie und Kryptographie
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	**Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30 - 45 min. (with small number of participants) In the first lecture it will introduced, if the examination will organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Kombinatorik“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Informatik B.Sc.: Compulsory elective module in „Praktische Mathematik" or in field of application „Mathematics" • Study programme Informatik M.Sc.: Compulsory elective module in „Mathematik" or in field of application „Mathematik" • Study programme Cyber Security M.Sc.: Compulsory elective module in complex „Computer Science“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Combinatorics“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science“
Module Components	• Lecture *Coding Theory*, with integrated exercise • Related examination
Components to be offered in the Current Semester	No assignment

Module 13949 Differential Geometry

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13949	Compulsory elective

Modul Title	**Differential Geometry** Differentialgeometrie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Breuß, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students are familiar with the basic concepts and techniques of differential geometry and able to apply the appropriate techniques.
Contents	• Euclidean geometry • Curve geometry • Classic planar theory • Inner planar geometry • Connection of geometry with calculus and topology
Recommended Prerequisites	Knowledge of the content of the modules • 11103: *Analysis I* • 11104: *Analysis II* • 11101: *Lineare Algebra und analytische Geometrie I*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Martin Lipschutz, Schaum's Outline of Differential Geometry, Schaum Outline Series
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of homework (50% of points must be reached)

	Final module examination: • Written examination, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Kombinatorik“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Combinatorics“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“
Module Components	• Lecture: Differential Geometry • Accompanying exercise • Related examination
Components to be offered in the Current Semester	No assignment

Module 13978 Bioinformatics: Artificial Intelligence and Algorithmic Approaches

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13978	Compulsory elective

Modul Title	**Bioinformatics: Artificial Intelligence and Algorithmic Approaches** Bioinformatik: Methoden aus Künstlicher Intelligenz und Algorithmik
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will have acquired an introduction to modern bioinformatics and to selected applications from biology and medicine. They understand the methodology through presentation of the central computational problems and an introduction of solutions based on classical algorithms and statistical machine learning, as well as modern deep learning approaches.
Contents	The focus will be on four fundamental problem areas: • Comparing sequences: Sequence alignment algorithms, Genome-scale approaches using index data structures, Alignment-free methods • Analyzing gene expression: alignment-based and alignment-free methods to analyzing RNASeq, single-cell analysis • Signals in sequences: identification of motifs, accessibility, and modification of DNA • Sequence variations and relation to phenotypes: structural variants in disease, pan-genome approaches
Recommended Prerequisites	• Basic knowledge of probability and statistics, algorithms and data structures at the undergraduate level • Introduction to machine learning at Master's level • Working knowledge of Python • Knowledge of the contents of module 14336 *Introduction to Bioinformatics*
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Study project - 30 hours Self organised studies - 90 hours
Teaching Materials and Literature	• Biological Sequence Analysis. Cambridge University Press (Exerpts) • Genome-Scale Algorithm Design. Cambridge University Press (Exerpts) • Review and Original Research Articles for the ML aspects
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be announced, the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture „Bioinformatics: AI and Algorithmic Approaches“ • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**100040** Lecture/Exercise Bioinformatics: Artifical Intelligence and Algorithmic Approaches - 4 Hours per Term **100041** Examination Bioinformatics: Artifical Intelligence and Algorithmic Approaches

Module 14023 Modeling of Perception and Action

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14023	Compulsory elective

Modul Title	**Modeling of Perception and Action** Modellierung von Wahrnehmung und Handlung
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Glasauer, Stefan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students know the subject and the methods of analysis, modelling and simulation of perception and action processes at different levels of abstraction. They have knowledge of probabilistic models and the mathematical modelling of questions in cognitive neuroscience and can understand and apply algorithms and solution strategies.
Contents	• Introduction to modelling software • Elementary principles of probability theory • Examples of experimental analysis of perceptual and action processes - Multisensory perception - Context dependence of perceptual processes - Action control • Quantitative modelling of perception, decision-making and action processes - Sensory systems - Central processing of sensory impressions - Decision-making and action control
Recommended Prerequisites	Knowledge of the topics of the modules • 11112 *Mathematik IT-1 (Diskrete Mathematik)* • 11113 *Mathematik IT-2 (Lineare Algebra)* • 11213 *Mathematik IT-3 (Analysis)* • 11756 *Algorithmen und Datenstrukturen*
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Will be announced by the lecturer in the first class meeting.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of exercises **Final Module Examinatio:** • Written exam, 120 minutes **OR** • Oral examination, 30-45 minutes In the first lecture it is announced, whether the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	100
Remarks	• Study programme Medizininformatik: B.Sc.: Compulsory elective module in complex „Informatik" • Study programme Informations- und Medientechnik B.Sc.: Complex „Informatik", compulsory elective module module in the field of study „Kognitive Systeme" • Study programme Informatik B.Sc.: Compulsory elective module in complex „Praktische Informatik" (level 300) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“
Module Components	• Lecture: Modellierung von Wahrnehmung und Handlung • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**140330** Lecture Modeling of Perception and Action - 2 Hours per Term **140331** Exercise Modeling of Perception and Action - 2 Hours per Term **140334** Examination Modeling of Perception and Action

Module 14085 Graph Theory

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14085	Compulsory elective

Modul Title	**Graph Theory** Graphentheorie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Köhler, Ekkehard
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Each winter semester odd year
Credits	8
Learning Outcome	The students • Know the most important terms and connections of graph theory • Are able to apply graph theoretical concepts to solve practical problems • Used the example of graph theroretic topics to attain experience in self-contained scientific working
Contents	• Basic concepts, graphs, connectivity, trees • Matchings, colorings, flows • Hall's theorem, König's theorem, chromatic number, Menger's theorem • Planar graphs, Euler characteristic, Kuratowski's theorem, duality, cycle bases • Ethical responsibility in the application of models, algorithms and results
Recommended Prerequisites	Knowledge of the content of the modules • 11101: Lineare Algebra und analytische Geometrie I • 11102: Lineare Algebra und analytische Geometrie II or • 11112: Mathematik IT-1 (Diskrete Mathematik) • 11113: Mathematik IT-2 (Lineare Algebra)
Mandatory Prerequisites	• No successful participation in module 11415 Graphtheorie
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• D.B. West: Introduction to Graph Theory. (Prentice Hall, 1996) • R. Diestel: Graphentheorie. (Springer,1996)
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite for final module examination:** • Successful completion of homework **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30 min. In the first lecture it will be announced, whether the examination will be organized in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Kombinatorik“ • Study programme Mathematics M.Sc.:Compulsory elective module in complex „Analysis / Algebra / Combinatorics“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science“ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend • Study programme Informatik B.Sc.: Compulsory elective module in „Praktische Mathematik“ or in field of application „Mathematik“ • Study programme Informatik M.Sc.: Compulsory elective module in „Mathematik“ or in field of application „Mathematik“ • Study programme Künstliche Intelligenz B.Sc.: Compulsory elective module in complex „Wissensakquise, -repräsentation und -verarbeitung“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme“ • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“
Module Components	• Lecture: Graph Theory • Accompanying exercises • Related examination

Components to be offered in the Current Semester	**130470** Examination Graph Theory - Reexamination - 2 Hours per Term

Module 14186 Image Processing and Computer Vision

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14186	Compulsory elective

Modul Title	**Image Processing and Computer Vision** Bildverarbeitung und Computer Vision
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Breuß, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students are acquainted with basic and advanced techniques and mathematical models for processing digital image data and dealing with various computer vision tasks.
Contents	In the lectures theory and methods are presented. The material is illustrated in the tutorial at hand of typical problems in the field. In a study project the students deepen their knowledge about given techniques. Main topics are: • Mathematical description of images and basic as well as advanced image filtering operations • Algorithms and theory for selected image transformations, e.g. Fourier transform and morphological filters • Introduction into a selection of important computer vision tasks and methods, e.g. in optical flow, object detection, object tracking, segmentation
Recommended Prerequisites	Knowledge of the content of modules • 11113 Mathematik IT-2 (Lineare Algebra) • 11213 Mathematik IT-3 (Analysis)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Study project - 60 hours

	Self organised studies - 60 hours
Teaching Materials and Literature	none
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of study project tasks **Final module examination:** • Written examination, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Knowledge Acquisition, Representation, and Processing“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science“
Module Components	none
Components to be offered in the Current Semester	**130330** Lecture Image Processing and Computer Vision - 2 Hours per Term **130331** Exercise Image Processing and Computer Vision - 2 Hours per Term **130332** Examination Image Processing and Computer Vision

Module 14414 Data Analytics and Process Modelling

assign to: Knowledge Acquisition, Representation, and Processing

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14414	Compulsory elective

Modul Title	**Data Analytics and Process Modelling** Datenanalyse und Prozessmodellierung
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Röntzsch, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The students learn to develop, evaluate and validate models, design experiments and analyse data. The focus is placed on practical applications, particularly in process and energy technology. Students are also familiarised with soft sensors and digital twins.
Contents	1. Basic Descriptive Statistics and Data Visualisation 2. Theoretical Foundation for Statistical Analysis 3. Regression Analysis 4. Design of Experiments 5. Input-State-Output Systems 6. Process Modelling and System Identification 7. Soft Sensors and Digital Twins
Recommended Prerequisites	Knowledge of advanced mathematics as well as physics or a basic engineering subject (e.g. electrical engineering, mechanics or thermodynamics) at the university bachelor's level
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The course materials will be provided through Moodle. Literature: • Shardt, Yuri: Statistics for Chemical and Process Engineers. A Modern Approach. 2nd edition (2022). DOI: 10.1007/978-3-030-83190-5.

- Shardt, Yuri (2023): Using MATLAB to Solve Statistical Problems. DOI: 10.1007/978-3-031-40299-9.
- Shardt, Yuri (2024): Using Excel to Solve Statistical Problems. DOI: 10.1007/978-3-031-65449-7.

Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written exam (120 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The students should bring a laptop for the exercises.
Module Components	• Lecture/exercise Data Analytics and Process Modelling • Exam Data Analytics and Process Modelling
Components to be offered in the Current Semester	**320470** Examination Data Analytics and Process Modelling

Module 11847 Neural Networks and Learning Theory

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	11847	Compulsory elective

Modul Title	**Neural Networks and Learning Theory** Neuronale Netze und Lerntheorie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil Meer, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Each summer semester even year
Credits	8
Learning Outcome	Students will get insight into different network architectures and their principles of operation. Notions like artificial intelligence and automatic learning will be made precise during the course. A central issue is the understanding of mathematical ideas underlying different network learning algorithms. This includes both positive solutions of problems and knowledge about limits of the approaches studied.
Contents	Some central network architectures are treated. These architectures differ in the way they manipulate input data, the way they perform learning tasks and the analysis of corresponding algorithms by mathematical means. More precisely, the following types of networks are covered: • General aspects of architecures, in particular feedforward nets, recurrent nets • Perceptron network, perceptron learning algorithm • Backpropagation algorithm • Radial basis function networks • Support Vector Machines • Learning theory and Vapnik-Chervonenkis dimension • Self-organizing networks • Hopfield networks Special emphasis will be given to the mathematical analysis of algorithms. This will make it necessary to study some basic facts of optimization and probability theory.

Recommended Prerequisites	Basic knowledge both concerning optimality criteria in differentiable optimization and probability theory are advisable, but will be treated briefly in the course. Solid knowledge of the content of module • 11213: Mathematik IT -3 (Analysis)
Mandatory Prerequisites	No successful participation in associated phase-out module 12450 *Neuronale Netze und Lerntheorie*.
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• E. Alpaydin: Maschinelles Lernen, Oldenbourg Verlag München, 2008 • M. Anthony, N.Biggs: Computational Learning Theory, Cambridge University Press 1997 • N. Christiani, J. Shawe-Taylor: An Introduction to Support Vector Machines and kernel-based Learning Methods, Cambridge Univ. Press, 2003 • A.C.C Coolen, R. Kühn, P. Sollich: Theory of Neural Information Processing Systems, Oxford University Press 2005 • P. Fischer: Algorithmisches Lernen, Teubner 1999 • P. Flach: Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Cambridge University Press 2012 • F. M. Ham, I. Kostanic: Principles of Neurocomputing for Science & Engineering, McGraw Hill 2001 • S. Haykin: Neural Networks, Prentice Hall, 1999 • R. Rojas: Theorie der neuronalen Netze, Springer 1996 • S. Shalev-Shwartz, S. Ben-David: Understanding Machine Learning, Cambridge University Press 2014.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of homework (fortnightly) and/or successful completion of tests (approx. 4 tests of 15-30 minutes each, written during the lecture period) **Final module examination:** • Written examination, 90 min. **OR** • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	100
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex „Grundlagen der Informatik" (level 400) • Study programme Cyber Security M.Sc.: Compulsory elective module in complex „Computer Science"

- Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“
- Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Kognitions- und Neurowissenschaft“
- Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Analysis / Algebra / Kombinatorik“
- Study programme Mathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend
- Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Vertiefung“, in limited extend
- Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“
- Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science“

Module Components

- Lecture: Neural Networks and Learning Theory
- Accompanying exercise
- Related examination

Components to be offered in the Current Semester

120120 Lecture
Neural Networks and Learning Theory - 4 Hours per Term
120121 Exercise
Neural Networks and Learning Theory - 2 Hours per Term
120122 Examination
Neural Networks and Learning Theory

Modul 12472 Einführung in die Constraint-Programmierung

zugeordnet zu: Learning and Reasoning

Studiengang Artificial Intelligence

Akademischer Grad	Modulnummer	Modulform
Master of Science	12472	Wahlpflicht

Modultitel	**Einführung in die Constraint-Programmierung** Introduction to Constraint Programming
Einrichtung	Fakultät 1 - MINT - Mathematik, Informatik, Physik, Elektro- und Informationstechnik
Verantwortlich	Prof. Dr. rer. nat. habil. Hofstedt, Petra
Lehr- und Prüfungssprache	Deutsch
Dauer	1 Semester
Angebotsturnus	jedes Wintersemester
Leistungspunkte	6
Lernziele	Die Studierenden erlangen einen theoretisch fundierten Überblick über das Gebiet der Constraint-Programmierung sowie praktische und methodische Kenntnisse und Fähigkeiten in der Anwendung. Sie lernen Techniken und mathematische Grundlagen von Constraint-Solving-Verfahren kennen. Weiterhin werden sie befähigt, komplexe Constraint-Probleme (Optimierung, Planung, Logistik, Diagnose) zu abstrahieren, zu modellieren und zu implementieren. Dies schließt die Fähigkeit zur Auswahl geeigneter Techniken und Methoden für spezielle Anwendungsbereiche ein.
Inhalte	Die Veranstaltung umfasst u.a. folgende Themengebiete: • Prädikatenlogik und Logikprogrammierung, • Constraints, Constraint-Systeme und Constraint-Domänen, • Spezielle Constraint-Lösungsmechanismen und Algorithmen, insbesondere Finite-Domain Constraints und arithmetische Constraints, • globale Constraints, • Constraint-Programmiersprachen (Syntax und Semantik), • Praktische Anwendung der Constraint-Programmierung und Modellierung, • Heuristische Suche und Optimierung.
Empfohlene Voraussetzungen	Grundkenntnisse in Logik und in der Programmierung
Zwingende Voraussetzungen	keine
Lehrformen und Arbeitsumfang	Vorlesung - 2 SWS

	Übung - 2 SWS Selbststudium - 120 Stunden
Unterrichtsmaterialien und Literaturhinweise	• P. Hofstedt, A. Wolf: Einführung in die Constraint-Programmierung. Grundlagen, Methoden, Sprachen, Anwendungen. Springer 2007. Aktuelle Literaturhinweise sind auf der Web-Seite zur Lehrveranstaltung zu finden.
Modulprüfung	Modulabschlussprüfung (MAP)
Prüfungsleistung/en für Modulprüfung	• mündliche Prüfung, 30-45 min. **ODER** • Klausur, 90 min. (bei erhöhter Teilnehmerzahl) In der ersten Lehrveranstaltung wird bekanntgegeben, ob die Prüfungsleistung in schriftlicher oder mündlicher Form zu erbringen ist.
Bewertung der Modulprüfung	Prüfungsleistung - benotet
Teilnehmerbeschränkung	keine
Bemerkungen	• Studiengang Informatik M.Sc.: Wahlpflichtmodul im Komplex „Praktische Informatik“ (Niveaustufe 400) • Studiengang Artificial Intelligence M.Sc.: Wahlpflichtmodul im Komplex „Learning and Reasoning“ • Studiengang Künstliche Intelligenz Technologie M.Sc.: Wahlpflichtmodul im Komplex „Software-basierte Systeme“ • Studiengang Angewandte Mathematik M.Sc.: Wahlpflichtmodul im Komplex „Anwendungen“, Bereich „Informatik“
Veranstaltungen zum Modul	• Vorlesung: Einführung in die Constraint-Programmierung • Übung zur Vorlesung • Zugehörige Prüfung
Veranstaltungen im aktuellen Semester	**120762** Prüfung Einführung in die Constraint-Programmierung

Module 12826 Mathematical Data Science

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	12826	Compulsory elective

Modul Title	**Mathematical Data Science** Mathematische Grundlagen der Data Science
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Hartmann, Carsten
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	After successfully completing the module, students have deepened their knowledge of stochastics acquired in the basic modules. They know the mathematical and statistical methods from data analysis. They have acquired basic skills for in-depth modules in stochastics or optimization. They have gained experience in doing independent research.
Contents	Choice of the following topics • Concentration of random vectors in high dimensions • Concentration inequalities • Linear and nonlinear principal component analysis (PCA) • Random matrices • Sparse recovery (compressed sensing) and LASSO regression • Introduction to statistical learning • Kernel methods and Gaussian processes • Applications in signal and image processing, random networks, …
Recommended Prerequisites	Knowledge of the content of the modules • 11103 : Analysis I • 11104 : Analysis II • 11101 : Lineare Algebra und analytische Geometrie I • 11217 : Wahrscheinlichkeitstheorie or very good knowledge of the content of the modules • 11113: Mathematics IT-2 (Linear Algebra) • 11213: Mathematics IT-3 (Analysis) • as well as of the content one of the modules - 11917 : Mathematik W-3 (Statistik)

- 11926 : Statistik für Anwender
- 11212 : Statistics

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 4 hours per week per semester
Exercise - 2 hours per week per semester
Self organised studies - 150 hours

Teaching Materials and Literature

- C.M. Bishop. Pattern Recognition and Machine Learning. Springer, 2006.
- D.P. Dubhashi, A. Panconesi. Concentration of Measure for the Analysis of Randomized Algorithms, Cambridge University Press, 2009.
- R. van Handel. Probability in High Dimension. Lecture Notes, Princeton University, 2016.
- R. Vershynin. High-Dimensional Probability: An Introduction with Applications in Data Science, Cambridge University Press, 2018

Module Examination

Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination

Prerequisite:
- Successful completion of a semester project

Final module examination:
- Project presentation, 45 min.

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

- Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Stochastics“ or in complex „Optimization “
- Study programme Mathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend
- Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend
- Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“
- Study programme Informatik B.Sc.: Compulsory elective module in „Applied Mathematics“ or in field of application „Mathematics“
- Study programme Informatik M.Sc.: Compulsory elective module in „Mathematics“ or in field of application „Mathematics“
- Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“

Module Components

- Lecture: Mathematical Data Science
- Accompanying exercise

Components to be offered in the Current Semester

130810 Lecture
Mathematical Data Science - 4 Hours per Term
130811 Exercise
Mathematical Data Science - 2 Hours per Term
130812 Exercise
Mathematical Data Science - 2 Hours per Term

130813 Examination
Mathematical Data Science
130893 Examination
Mathematical Data Science (Wiederholung)

Module 13335 Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13335	Compulsory elective

Modul Title	**Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology** Brain-Computer-Interfaces für Neuroadaptive Technologien
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Zander, Thorsten O.
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successfully completing the module, students possess a basic understanding of the methodology of Brain-Computer Interfaces (BCIs), including measurement of brain activity, signal processing, machine learning and the principle of automated interpretation of brain activity to assess information of changes in cognitive states. Furthermore, they are familiar with the use of BCIs in current and to-be-created human-computer interactions which includes the current development of beneficial Artificial Intelligence.
Contents	The module will consist of lectures describing the methodology and use of Brain-Computer Interfaces from the scratch. This includes knowledge from machine learning and signal processing, as well as psychophysiology and psychology, and human-computer interaction. In the seminar, students will be introduced to AI safety and the ethics of neurotechnology, and will prepare group presentations on various related topics and issues. Ethical issues and social consequences are discussed and guidelines for research and development are derived.
Recommended Prerequisites	none
Mandatory Prerequisites	Passing the exam of module • 13942: Foundations of Psychophysiology
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Zander, T. O. (2011). Utilizing Brain-Computer Interfaces for Human-Machine Systems (Doctoral dissertation, Universitätsbibliothek der Technischen Universität Berlin).
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• active participation by asking questions during or after the classes (20%) • moderated discussion of selected topics related to the lecture, 45 minutes (30%) • written exam, 60 minutes (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	72
Remarks	• Study programme Medizininformatik: B.Sc.: Compulsory elective module in complex „Medizininformatik" • Study programme Informatik M.Sc.: Compulsory elective module in complex „Praktischer Informatik" (level 400) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Künstliche Intelligenz Technologie B.Sc.: Compulsory elective module in complex „Kognitions- und Neurowissenschaft“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Applications“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications: Computer Science & Artificial Intelligence“
Module Components	• Lecture: Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology • Accompanying seminar
Components to be offered in the Current Semester	**142110** Lecture Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology - 2 Hours per Term **142112** Seminar Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology - 2 Hours per Term **142114** Examination Brain-Computer Interfaces (BCIs) for Neuroadaptive Technology

Module 13569 Biological Neuronal Networks

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13569	Compulsory elective

Modul Title	**Biological Neuronal Networks** Biologische Neuronale Netzwerke
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Glasauer, Stefan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students will be familiar with major topics of the current state of knowledge on biological neuronal networks from the neuroanatomical and neurophysiological point of view and to leading theoretical concepts about how biological neuronal networks operate and fulfill their diverse functions.
Contents	• Neurons as constituents of biological neuronal networks • Synapses: the connection between neurons, more than just a summation point • The role of dendritic trees and neuron morphology • Examples of biological neuronal networks: the cerebellum, the head direction cell system, the hippocampus, cortical columns, etc. • Experimental approaches to understanding biological neuronal networks • Theoretical and computational approaches
Recommended Prerequisites	Knowledge of the topics of the modules • 11112 *:* Mathematics IT-1 (Discrete Mathematics) • 11113 : Mathematics IT-2 (Linear Algebra) • 11213 : Mathematics IT-3 (Analysis) • 11756 : Algorithms and Data Structures, or 12101 : Algorithmieren und Programmieren
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	• Gerstner W, Kistler WM, Naud R, Paninski L.: Neuronal Dynamics – From single neurons to networks and models of cognition, Cambridge University Press (2014), https://neuronaldynamics.epfl.ch
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written exam, 120 min. **OR** • oral examination, 30-45 min. In the first class meeting it will be announced whether the examination is to be taken in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	100
Remarks	• Study programme Informatik B. Sc.: Compulsory elective module in "Praktische Informatik" (level 300) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“ • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications: Natural Sciences and Engineering“
Module Components	• Lecture: Biological Neuronal Networks • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**140320** Lecture Biological Neuronal Networks - 2 Hours per Term **140321** Exercise Biological Neuronal Networks - 2 Hours per Term **140324** Examination Biological Neuronal Networks

Module 13846 Learning in Real and Virtual Humans

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13846	Compulsory elective

Modul Title	**Learning in Real and Virtual Humans** Lernen bei organischen und virtuellen Menschen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successfully completing the module, students will master a solid, conceptual framework for understanding the elements of learning and related higher cognitive functions as well as their implementations in humans and machines. In particular, they will be able to describe the types learning required for higher cognitive functions, along with the memory and reasoning requirements. Furthermore, they will understand the various classes of learning cognitive virtual agents with a strong focus on embodied conversational agents. By the end of the course, participants are able to use what they learned to subsequently deepen their studies of the various topics.
Contents	Basics of perception and action coupling and embodied cognition, memory (iconic, working, short- and long-term), evolutional learning, neural plasticity, behaviorism vs cognitive psychology approaches to learning, classical conditioning, habituation, operant conditional, concepts and knowledge, problem solving, basics of reasoning and judgment, fundamentals of language, basics of personality theory, ethical and social aspects in connection with the teaching content
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Michael Eysenck: Fundamentals of Cognition, 2nd Edition, Psychology Press Ltd. (2012) • Russell, S., and P. Norvig: Artificial Intelligence: A Modern Approach, global edition 4th., Pearson Education Limited, Harlow UK (2021) • Cassell, Justine & Sullivan, Joseph & Prevost, Scott & Churchill, Elizabeth: Embodied Conversational Agents (2000)
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“
Module Components	• Lecture: Learning in Real and Virtual Humans • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**120910** Lecture Learning in Real and Virtual Humans - 2 Hours per Term **120911** Exercise Learning in Real and Virtual Humans - 2 Hours per Term **120912** Examination Learning in Real and Virtual Humans

Module 13847 Cognitive Systems: Behavior Control

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13847	Compulsory elective

Modul Title	**Cognitive Systems: Behavior Control** Kognitive Systeme: Verhaltenssteuerung
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr.-Ing. habil. Wolff, Matthias
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successfully completing the module, students can understand and develop techniques for semantics processing, methods for automatic planning and decision making under uncertainties, and the behavior control of cognitive technical systems.
Contents	• Unsupervised learning, strategy learning (Q-learning) • Markov decision processes (MDP) • Partially observable Markov decision processes (POMDP) • Bidirectional signal processing • Semantic modeling with feature-value relations • Petri-net transducers as semantic carriers • Modeling of higher cognitive processes (e.g. coping) • Applications in communications and dialog systems
Recommended Prerequisites	Knowledge of the content of module • 11744 *Kognitive Systeme: Perzeption und Aktion*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Seminar - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Haykin, S.; Cognitive Dynamic Systems, Cambridge University Press, 2012

- Ertel, W.: Grundkurs Künstliche Intelligenz, 2. Überarbeitete Auflage 2009, Vieweg+Teubner Verlag ISBN: 978-3-8348-0783-0.
- R. Hoffmann, M. Wolff: Intelligente Signalverarbeitung 2: Signalerkennung, 2. Auflage. Springer Vieweg, 2015. ISBN 978-3-662-46725-1.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Processing of a seminar task in groups and presentation, approx. 10 minutes with subsequent technical discussion (25 %)
  (Solution of a programming task on the topic of the lecture and preparation of a presentation in self-study; presentation scheduled in the course of the lecture, usually on the last exercise date)
- written examination, 60 minutes (75 %)

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

120

Remarks

- Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“
- Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Kognitions- und Neurowissenschaft“
- Study programme Informatik M.Sc.: Compulsory elective module in field of application „Maschinenbau/Elektrotechnik“
- Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications: Computer Science & Artificial Intelligence“

Module Components

- Lecture: Cognitive Systems: Behavior Control
- Accompanying exercise
- Related examination

Components to be offered in the Current Semester

110441 Lecture
Cognitive Systems: Behavior Control / Kognitive Systeme: Verhaltenssteuerung - 2 Hours per Term
110442 Seminar/Exercise
Cognitive Systems: Behavior Control / Kognitive Systeme: Verhaltenssteuerung - 2 Hours per Term

Module 13906 Data Exploration and System Management Using Artificial Intelligence / Machine Learning

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13906	Compulsory elective

Modul Title	**Data Exploration and System Management Using Artificial Intelligence / Machine Learning** Datenexploration und Systemmanagement mit Künstlicher Intelligenz / Maschinellem Lernen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. hab. Jablonski, Ireneusz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After completion of the module, students will have an overview of the basic operations available for processing datasets measured in systems of any nature (e.g., physical, technical, biological, financial, etc.) and will be able to relate these operations to AI/ML-based methods and tools dedicated to a specific task. The students understand real world problems and can explain them using computer simulations. They know how to apply the acquired knowledge to an individual project, including increased skills in preparing project documentation and public presentation.
Contents	The subject of the module are the classes of real-world problems that can be solved by data exploration using AI/ML methods. This includes, for example, anomaly/outlier detection, data decomposition and feature selection, data fusion, prediction, decision support. A mapping between problems and available AI/ML methods will be presented. The project consists in solving a self-defined problem using a selected AI/ML technique and computer simulations. The software procedure together with a project report will be created by student.
Recommended Prerequisites	• Knowledge of mathematics, especially statistics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Study project - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Hastie T., Tibshirani R., Friedman J.: The elements of statistical learning. Data mining, inference, and prediction. Springer, 2nd edition, New York 2009. • Kulkarni S., Harman G.: Elementary introduction to statistical learning theory. Wiley & Sons Inc., New Jersey 2011.
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of the project task, 30 h **Final module examination:** • Written examination, 90 min. OR • Oral examination, 30-45 min. (with small number of participants) In the first lecture it will be announced, wheter the examination will be organised in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“
Module Components	• Lecture: Data exploration and system management using AI/ML • Accompanying project • Related examination
Components to be offered in the Current Semester	No assignment

Module 13942 Foundations of Psychophysiology

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13942	Compulsory elective

Modul Title	**Foundations of Psychophysiology** Grundlagen der Psychophysiologie
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Zander, Thorsten O.
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successfully completing the module, students possess an understanding of the physiological processes in the human body that lead to biomarkers of different mental states. They furthermore understand the principles of experimental design in the context of psychophysiology, and have experience reading, critiquing, and writing psychophysiological research literature.
Contents	The module consists of lectures and a seminar. The lectures cover relevant aspects of general human physiology as well as more specific processes that can be measured using electrocardiography (ECG, heart activity), electromyography (EMG, muscle activity), electrodermal activity (EDA, skin conductance), eye tracking, as well as brain activity through functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG). The techniques behind each of these methods are discussed as well, along with properties of the recorded signal and some known correlates of that signal to mental processes or psychological states. Ethical, social and legal issues arising from research into the use of psychophysiological data will be discussed. This includes the recording of data, data security, transparency and ethical issues relating to experiments. In the seminar, students will read, present and discuss relevant papers published in scientific journals, reflecting different experiments involving physiological data. Additionally, students will write an essay on a related topic.
Recommended Prerequisites	none

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Andreassi, J. (2007). Psychophysiology: Human Behavior and Physiological Response (5th Edition). New York, NY, USA: Psychology Press • Gramann, K. & Schandry, R. (2009). Psychophysiologie (4. Auflage). Basel, Switzerland: Beltz • Selected scientific papers
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• written test, 60 minutes (60%) • term paper, 6 pages (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	72
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Kognitions- und Neurowissenschaft“ • Study programme Medizininformatik B.Sc.: Compulsory elective module in complex „Medizininformatik“ • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Applications“ • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Data Science Applications“
Module Components	• Lecture: Foundations of Psychophysiology • Accompanying seminar
Components to be offered in the Current Semester	**142120** Lecture Foundations of Psychophysiology - 2 Hours per Term **142121** Seminar Foundations of Psychophysiology - 2 Hours per Term **142124** Examination Foundations of Psychophysiology

Module 14021 Explainable Machine Learning

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14021	Compulsory elective

Modul Title	**Explainable Machine Learning** Erklärbares Maschinelles Lernen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. biol. hum. Schneider, Erich
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students understand the interpretability and explainability of machine learning systems. They master methods of interpretability and can optimise systems for interpretability. They are able to implement interpretability and explainability mechanisms for machine learning systems.
Contents	The most significant disadvantage of machine learning and deep learning algorithms today: the interpretability of models. To trust predictions of real-life applications of AI it is important to understand how (Explainability) and why (Interpretability) a prediction is made. • Key Concepts of Interpretability and Explainability Challenges • Fundamentals of Feature Importance and Impact • Global and Local Model-Agnostic Explainability Methods • Anchor and Counterfactual Explanations • Visualizing Convolutional Neural Networks • Interpretation Methods for multivariate Forecasting and Sensitivity Analysis • Tuning for Explainability
Recommended Prerequisites	Basic knowledge of programming and machine learning
Mandatory Prerequisites	Knowledge of the content of module • 11881: Foundations of Data Mining or • 12351: Grundlagen des Data Mining

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Laboratory training - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Script and presentations are available for download in Moodle at the beginning of the semester and on an ongoing basis. Problems for exercises and instructions for lab experiments can be downloaded. • Serg Masis, Interpretable Machine Learning with Python: Learn to build interpretable high-performance models with hands-on real-world examples, Packt 2021 • Ajay Thampi, Interpretable Ai: Building Explainable Machine Learning Systems, Manning 2022 • Christoph Molnar, Interpretable Machine Learning: A Guide For Making Black Box Models Explainable, 2022 • Uday Kamath; John Liu, Explainable Artificial Intelligence: An Introductionto Interpretable Machine Learning, Springer 2021
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of exercises and presentation of results in course **Final module examination:** • Written examination, 120 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex „Angewandte und Technische Informatik" (level 400) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme“ • Study programme Cyber Security M.Sc.: Compulsory elective module in complex „Computer Science" • Study programme Medizininformatik B.Sc.: Compulsory elective module in complex „Informatik"
Module Components	• Lecture: Explainable Machine Learning • Accompanying laboratory • Accompanying Examination
Components to be offered in the Current Semester	**140224** Examination Explainable Artificial Intelligence

Module 14038 Computing at Scale in Machine Learning: Distributed Computing and Algorithmic Approaches

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14038	Compulsory elective

Modul Title	**Computing at Scale in Machine Learning: Distributed Computing and Algorithmic Approaches** Computing-at-Scale im Maschinellen Lernen: Verteiltes Rechnen und Algorithmische Ansätze
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successfully completing the module, students have an overview on how to solve large-scale computational problems in data science and machine learning. They know parallel approaches from multi-threaded computation on individual machines to implicit parallelism frameworks on compute clusters. They are familiar with algorithms and data structures supporting efficient exact or approximate (e.g. sketching) computation with massive data sets in and out of core. They are able to implement the algorithms. They can assess which methods can be used in a given situation.
Contents	The focus will be on the following areas: • A review of memory-compute co-location and its impact on big data computations. • Solving Machine Learning (ML) work loads using explicit parallelism, specifically multi-threaded computation on an individual machine. • Introduction of implicit parallelism programming models as implemented for example in MapReduce, Spark and Ray and their application in ML. • Probabilistic algorithms such as sketching algorithms (incl. CountMinSketch, Hy-perLogLog) or Bloom filters. • Implementing ML methods using index data structures such as suffix or kd-trees.suffix or kd-trees.
Recommended Prerequisites	• Good working knowledge of discrete probability, algorithms and data structures at the undergraduate level is absolutely necessary

	• Introduction to machine learning at Master's level • Advanced knowledge of programming in Python and the Linux command line
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Study project - 30 hours Self organised studies - 90 hours
Teaching Materials and Literature	• Data Science Design Manual. S. Skiena. Springer (Exerpts) • Parallel Programming for Multicore and Cluster Systems. T. Rauber and G. Rünger. Springer (Exerpts) • Review and Original Research Articles
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination, 120 min. OR • Oral examination, 30-45 min. The nature of the examination will be announced in the first lecture.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Informatik M.Sc.: Compulsory elective module in complex „Praktische Informatik"(level 400) • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning"
Module Components	• Lecture: Computing at Scale in Machine Learning: Distributed computing and algorithmic approaches • Accompanying exercise • Related examination
Components to be offered in the Current Semester	**100062** Examination Computing at Scale in Machine Learning: Distributed computing and algorithmic approaches (Wiederholung)

Module 14356 Differentiable Optimization

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14356	Compulsory elective

Modul Title	**Differentiable Optimization** Differenzierbare Optimierung
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Wachsmuth, Gerd
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	After successful completion of the module, students know the problem types of differentiable optimization as well as the theory and procedures of differentiable optimization. They can create and evaluate different formulations of a problem, as well as select and evaluate appropriate procedures. By working out a project, they have gained experience in independent scientific work. By presenting the results to the group, they have learned how to present and communicate mathematical results.
Contents	**Unrestricted optimization** Optimality criteria, sensitivity, line search methods (e.g. gradient methods, CG methods, Newton methods, Quasinewton methods) and trust region methods, as well as their globalisations **Restricted optimization** Karush-Kuhn-Tucker theory (first and second order constraints, regularity), sensitivity, penalty and barrier methods, augmented Lagrangian methods, Lagrangian-Newton methods, SQP methods, nonlinear interior point methods Studnets gain experience in independent scientific work by working out a project, and learn how to present and communicate mathematical results by presenting the results to the group. • Development of a project (independent scientific work) • Presentation of the results to the group (presentation and communication of mathematical results)
Recommended Prerequisites	Knowledge of the content the modules • 11103: Analysis I

	• 11104: Analysis II • 11101: Lineare Algebra und analytische Geometrie I • 11102: Lineare Algebra und analytische Geometrie II • 13862: Optimierung und Operations Research
Mandatory Prerequisites	No successful participation in module 13392 Differenzierbare Optimierung.
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• W. Alt: Nichtlineare Optimierung. Vieweg, 2002. • C. Geiger, Ch. Kanzow: Numerische Verfahren zur Lösung unrestringierter Optimierungsaufgaben. Springer, 1999. • F. Jarre, J. Stoer: Optimierung. Springer, 2004. • J. Nocedal, S. Wright: Numerical Optimization. Springer, 1999. • M. Ulbrich, S. Ulbrich: Nichtlineare Optimierung. Springer, 2012
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of a project **Final module examination:** • Oral examination, 30 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective modul in complex „Learning and Reasoning" • Study programme Mathematics M.Sc.: Compulsory elective modul in complex „Optimization"
Module Components	• Lecture: Differentiable Optimization • Accompanying exercise • Related examination
Components to be offered in the Current Semester	No assignment

Module 14440 Causal Data Science

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14440	Compulsory elective

Modul Title	**Causal Data Science** Kausale Datenanalyse
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. Urbig, Diemo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students have a basic understanding of data science in the context of the identification of causal relationships. They are familiar with a verbal and graphical language to communicate about causality, and with key concepts, such as counterfactuals, outcome equivalence, and confounding effects. They know about typical classes of problems that do not allow causal interpretations of observed associations as well as typical solutions for these problems by means of data analytic and data collection methods. Moreover, students understand the tight interdependency of data analytics and the design of data collection to generate high-quality evidence and high-quality predictions.
Contents	1. Relationships and causal graphs 2. Identification of a causal effect and the potential outcome model 3. Estimation and testing of causal effect 4. Matching 5. Regression analysis, basics and nonlinear regression 6. Instrumental variables 7. Frondoor criterion 8. Selection bias and correction 9. Interrupted time series, regression discontinuity, fuzzy regression discontinuity 10. Panel data and fixed effects, first difference, dif-in-dif estimation 11. Experiments and quasi experiments The module focuses on applications in business and economics, but the underlying theories and methods generalize beyond these fields. The course complements more traditional data science modules with

	a stronger focus on implementing data-scientific algorithms. Tutorials also apply these methods to the analysis of real-world problems with simulated and real datasets. Currently, the freely available software [R] is used in the practical parts of the tutorials.
Recommended Prerequisites	• Basics of statistics, especially estimation and testing and simple regression analysis
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The lecture is based on selected chapters mostly from Morgan & Winship (2015). A few other articles or chapters will be provided during the module. Pearl, J. (2009) has become a classic reference in computer science. A more accessible introduction is found in Morgan & Winship (2015), the book on which most of the module is based. An accessible econometric perspective on some aspects of the module is offered by Angrist & Pischke (2014). More details on experiments can be found in Gerber & Green (2012). • Pearl, J. (2009). Causality. Cambridge University Press • Morgan, S. L., & Winship, C. (2015). Counterfactuals and causal inference. Methods and Principles for Social Research. Cambridge University Press. • Angrist, J. D., & Pischke, J. S. (2014). Mastering'metrics: The path from cause to effect. Princeton university press. • Gerber, A. S., & Green, D. P. (2012). Field experiments: Design, analysis, and interpretation. WW Norton. A few additional shorter articles or chapters might be provided during the course of the module.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• mid term examination, 45 min (35%) • end term examination, 75 min (65%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Tutorials are open to questions in English and German.
Module Components	• Lecture Causal Data Science – 2 Hours per Week per Semester • Exercice Causal Data Science – 2 Hours per Week per Semester
Components to be offered in the Current Semester	**530906** Lecture Vorlesung Causal Data Science - 2 Hours per Term **530907** Exercise Übung Causal Data Science - 2 Hours per Term

Module 14731 Combining Operations Research and Data Science

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14731	Compulsory elective

Modul Title	**Combining Operations Research and Data Science** Kombination von Operations Research und Data Science
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. Xie, Lin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	By the end of the course, students will be able to analyze and solve complex decision-making and optimization problems under uncertainty. They will be capable of selecting, combining, and adapting appropriate methods from Operations Research, Data Science, and Machine Learning. Additionally, they will be able to identify, evaluate, and apply suitable optimization algorithms to real-world problem settings.
Contents	• Introductory Case Study, Representing and Computing with Uncertain Quantities • Obtaining Probability Distributions and Probabilistic Machine Learning • Decision Making Under Uncertainty, the Value of Information • Optimization Under Uncertainty I: Two-Stage Stochastic Programming • Optimization Under Uncertainty II: Chance-Constrained Programming • Machine Learning for Algorithm Selection • Algorithm Configuration Home Assignments: • A new set of tasks (including formulating and implementing mathematical optimization models, writing and executing python code for simple machine learning tasks, etc) will be assigned **each week** for students to work on **independently at home**. • These homework tasks are **not mandatory**, but students are **strongly encouraged** to attempt them. • During the **exercise sessions**, selected homework problems will be discussed and solved collaboratively. • Students who **present solutions** (oral presentation) to homework problems during these sessions will earn **bonus points**.

	In the Exam students will be required to: • Provide the **mathematical formulation** of given problems. • Write the **pseudocode** for the solution of some tasks. • Answer **conceptual questions** related to the course content.
Recommended Prerequisites	• Basics of Python programming, • basics of linear programming, • basics of probability distributions
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	 - Santos, H.G., Toffolo, T.A.M., Silva, R.M., & Resende, M.G.C. Mixed Integer Linear Programming with Python. Retrieved from https://app.readthedocs.org/projects/python-mip/downloads/pdf/latest/ - Birge, J.R., & Louveaux, F. (1999). An introductory tutorial on stochastic linear programming models. Interfaces, 29(2), 33–44. https://doi.org/10.1287/inte.29.2.33 - Hutter, F., Kotthoff, L., & Vanschoren, J. (2018). Model evaluation, model selection, and algorithm selection in machine learning. arXiv preprint arXiv:1811.12808. Retrieved from https://arxiv.org/pdf/1811.12808
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written exam, 90 min. 100% exam + bonus points (maximum 10% of the final grade and only valid after passing the exam)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	Home Assignments: • A new set of tasks (including formulating and implementing mathematical optimization models, writing and executing python code for simple machine learning tasks, etc) will be assigned **each week** for students to work on **independently at home**. • These homework tasks are **not mandatory**, but students are **strongly encouraged** to attempt them. • During the **exercise sessions**, selected homework problems will be discussed and solved collaboratively. • Students who **present solutions** (oral presentation) to homework problems during these sessions will earn **bonus points**. These **bonus points** will be **added to the final grade**, but **only if the student passes the final exam**

Module Components	• Lecture • Exercise
Components to be offered in the Current Semester	**531020** Examination Combining Operations Research and Data Science (Wiederholungsprüfung)

Module 14906 Language Models: Machine Learning Basics to Modern Artificial Intelligence

assign to: Learning and Reasoning

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14906	Compulsory elective

Modul Title	**Language Models: Machine Learning Basics to Modern Artificial Intelligence** Sprachmodelle: von Grundlagen des maschinellen Lernens zur modernen Künstlichen Intelligenz
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Zander, Thorsten O.
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successful completion of the module students understand core concepts of supervised and unsupervised machine learning with a focus on NLP; can explain and implement representation-learning methods from word embeddings to Transformers; can critically compare assumptions, objectives, trade-offs, and failure modes; can discuss foundation model families (LLMs, VLMs, VLAs); can design basic experiments, evaluate models, and communicate results clearly.
Contents	• Artificial Intelligence: definitions, scope, history, limitations • Machine Learning vs. Deep Learning: formulations, data, losses, generalization; MNIST case study • NLP fundamentals: text as data, tokenization, representations • Word embeddings: motivation, distributional semantics, strengths and weaknesses • CNNs and RNNs: explanation, comparison and analysis • Transformers: self-attention intuition, components, impact • Language Models and LLMs: pretraining, scaling, evaluation, failure modes • Practical use of LMs: fine-tuning, prompting, RAG, reasoning behavior and constraints • Overview of multimodal models: VLMs, VLAs etc.
Recommended Prerequisites	• basic Python programming • basic linear algebra

	• basic probability/statistics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	- Bishop, Pattern Recognition and Machine Learning - Manning & Schütze, Foundations of Statistical Natural Language Processing
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• written examination, 90 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning” • Study programme Informatik M.Sc.: Compulsory elective module in complex „Angewandte und Technische Informatik” (Niveaustufe 400) • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Applications” • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Fundamentals of Data Science” • Study programme Micro- and Nanoelectronics M.Sc.: Compulsory elective module in complex „Applications” • Study programme Medizininformatik B.Sc.: Compulsory elective module in complex „Informatik”
Module Components	• Lecture: Language Models: Machine Learning Basics to Modern Artificial Intelligence • Accompanying seminar • Related examination
Components to be offered in the Current Semester	**142150** Lecture Language Models: Machine Learning Basics to Modern Artificial Intelligence - 2 Hours per Term **142151** Seminar Language Models: Machine Learning Basics to Modern Artificial Intelligence - 2 Hours per Term **142152** Examination Language Models: Machine Learning Basics to Modern Artificial Intelligence

Module 13866 Seminar

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13866	Compulsory elective

Modul Title	**Seminar** Seminar
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	4
Learning Outcome	After successfully completing the module, students will have acquired the skills needed to use computer science literature in order to familiarize themselves with a new, complex topic. They will be able to present the results, in oral as well as in written form.
Contents	State of the art in a complex subfield of artificial intelligence according to the topic of the seminar.
Recommended Prerequisites	Solid knowledge in the field of the seminar
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 60 hours
Teaching Materials and Literature	Literature references for individual retrieval will be provided at the beginning of the seminar.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 30-45 minutes (40 %) • Written report of the seminar presentation, 10-15 pages (40 %) • Active participation in courses (20 %)
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	none

Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400) • Study programme Informations- und Medientechnik M.Sc.: Compulsory elective module in complex „Informatik“ (seminar)
Module Components	Seminar in Artificial Intelligence to be chosen from current offer.
Components to be offered in the Current Semester	**140360** Seminar Theoretical Neuroscience - Master Seminar - 2 Hours per Term **142130** Seminar Neuroadaptive Technology - 2 Hours per Term

Module 13867 Seminar

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13867	Compulsory elective

Modul Title	**Seminar** Seminar
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	4
Learning Outcome	After successfully completing the module, students will have acquired the skills needed to use computer science literature in order to familiarize themselves with a new, complex topic. They will be able to present the results, in oral as well as in written form.
Contents	State of the art in a complex subfield of artificial intelligence according to the topic of the seminar.
Recommended Prerequisites	Solid knowledge in the field of the seminar.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 60 hours
Teaching Materials and Literature	Literature references for individual retrieval will be provided at the beginning of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 30-45 minutes (40 %) • Written report of the seminar presentation, 10-15 pages (40 %) • Active participation in courses (20 %)
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	none

Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex „Seminare oder Praktika“ (level 400)
Module Components	• varying seminar in Artificial Intelligence
Components to be offered in the Current Semester	**140360** Seminar Theoretical Neuroscience - Master Seminar - 2 Hours per Term **142130** Seminar Neuroadaptive Technology - 2 Hours per Term

Module 13868 Seminar

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13868	Compulsory elective

Modul Title	**Seminar** Seminar
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	4
Learning Outcome	After successfully completing the module, students will have acquired the skills needed to use computer science literature in order to familiarize themselves with a new, complex topic. They will be able to present the results, in oral as well as in written form.
Contents	State of the art in a complex subfield of artificial intelligence according to the topic of the seminar.
Recommended Prerequisites	Solid knowledge in the field of the seminar.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 60 hours
Teaching Materials and Literature	Literature references for individual retrieval will be provided at the beginning of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 30-45 minutes (40 %) • Written report of the seminar presentation, 10-15 pages (40 %) • Active participation in courses (20 %)
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	none

Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400)
Module Components	• varying seminar in Artificial Intelligence
Components to be offered in the Current Semester	**140360** Seminar Theoretical Neuroscience - Master Seminar - 2 Hours per Term **142130** Seminar Neuroadaptive Technology - 2 Hours per Term

Module 13869 Laboratory

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13869	Compulsory elective

Modul Title	**Laboratory** Praktikum
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will have acquired practical skills in oan area in Artificial Intelligence, in particular: • In-depth understanding of the state of knowledge in the corresponding field, • Ability to carry out projects (project planning, time management, communication, ...), • Ability to apply this knowledge and implement the relevant mechanisms, • Ability to collaborate with other developers.
Contents	The laboratory is implemented as a study project. For each project the following work steps have to be accomplished: • Getting acquainted with the state of the art • Project planning • Selecting the models and mechanisms to be used • Implementation of a prototype • Testing and evaluating the prototype • Documentation The course will explicitly discuss ethical and social frameworks in general as well as ethical and social considerations of machine learning in particular.
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Study project - 90 hours Self organised studies - 60 hours
Teaching Materials and Literature	Depending on the project the relevant information will be provided at the beginning of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 to 6 project tasks, each with an executable prototype and associated documentation The project tasks are weighted equally. - 75% of the total marks are needed to pass the module.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	none
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400)
Module Components	• Projects in the field of artificial intelligence
Components to be offered in the Current Semester	**120920** Practical training Braitenberg Vehikel Praktikum - 2 Hours per Term

Module 13979 Artificial Intelligence for Drug Design

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	13979	Compulsory elective

Modul Title	**Artificial Intelligence for Drug Design** Künstliche Intelligenz in der Medikamentenentwicklung
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	4
Learning Outcome	After successfully completing the module, students have insight into this exciting field of application for Artificial Intelligence (AI). They are able to acquire research literature and to present the topic orally as well as in a written report.
Contents	AI is revolutionizing drug design both for small molecule drugs - the prevalent drug modality - and novel modalities such as oligonucleotide therapeutics. Some of the progress has been achieved by transferring methods from established AI areas such as NLP. For other areas novel methodological developments were instrumental, with very exciting developments on the intersection between molecular dynamics and AI. The focus of the seminar will be on state-of-the-art methods and applications of AI in drug design for small molecule drugs and oligonucleotide therapeutics.
Recommended Prerequisites	Working knowledge of probability/statistics and modern machine learning methods.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	A list of original literature will be made available at the beginning of the semester.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• Seminar presentation, 30-45 min depending on the subject (40%) • Report on the topic of the seminar presentation, 10-15 pages (40%) • Active participation (20% of the total points) A student passes the module, if he/she achieves 75% of the total.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	25
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“
Module Components	• Seminar: AI for Drug Design
Components to be offered in the Current Semester	**100045** Seminar Artificial Intelligence for Drug Design - 2 Hours per Term

Module 14013 Conversational Artificial Intelligence: History, Application, Future

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14013	Compulsory elective

Modul Title	**Conversational Artificial Intelligence: History, Application, Future** Konversations Künstliche Intelligenz: Geschichte, Anwendung, Zukunft
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Langendörfer, Peter
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	4
Learning Outcome	After successfully completing the module, students have a comprehensive overview of the field of Conversational AI. Studnets know the history of NLP and chatbots, including the meaning of NLP, NLU, and NLG. They know text mining techniques using Matlab/Simulink, Python and R learn. They also have knowledge of large language models and multimodal models, and familiarity with Transformer models for deep learning. They know the limitations of models and new platforms such as ChatGPT, Baidu's Ernie, and Google's Bard and are able to build and maintain conversation-based agents.
Contents	The module provides a comprehensive overview of the field of Conversational AI. • History of natural language processing (NLP) and chatbots, including the meaning of NLP, NLU, • Introduction to text mining using Matlab/Simulink, Python, R • Large language models (LLM) and multimodal models • Transformer models for deep learning (DL), including generative pre-trained transformer (GPT-3), GPT-3.5, bidirectional encoder representations from transformers (BERT), Turing natural language generation (Turing-NLG), and Wu Dao 2.0 • Creating and managing a conversational agent with Google Dialogflow CX including flows, pages, intents, entities, fulfillments, and webhooks) • Cybersecurity aspects of chatbots, misinformation, and data biases

Recommended Prerequisites	• Basic knowledge of Python • Basic knowledge of machine learning
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• Will be handed out at the beginning of the semester / during the first seminar meeting.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 5-10 minutes (20%) • Paper/Essay, 10-15 pages (30%) • Successful completion of bi-weekly exercises (50%)
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	30
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex „Seminare oder Praktika“ (level 400)
Module Components	• Seminar: Conversational AI: History, Application, Future
Components to be offered in the Current Semester	**122270** Examination Conversational Artificial Intelligence: History, Application, Future - Re-Examination/Wiederholungsprüfung

Module 14051 Programming Languages and Techniques for Artificial Intelligence Laboratory

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14051	Compulsory elective

Modul Title	**Programming Languages and Techniques for Artificial Intelligence Laboratory** Praktikum Programmiersprachen und -techniken für die Künstliche Intelligenz
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Hofstedt, Petra
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	4
Learning Outcome	After successful completion of the module, students have acquired methods, skills, and experiences in the practical implementations of a restricted field in the area of programming languages in the context of artificial intelligence. They have mastered the use of technical documentation and are able to further develop their experience in teamworking and presenting results.
Contents	Implementation of development projects in small teams. Topics will be defined at the beginning of the semester.
Recommended Prerequisites	profound knowledge in programming
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Consultation - 1 hours per week per semester Practical training - 2 hours per week per semester Study project - 60 hours Self organised studies - 15 hours
Teaching Materials and Literature	Relevant references depend on the laboratory topic and will be announced at the first lecture on the course webpage and moodle, resp.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• the program components (50% of total marks) • documentation, 3-5 pages (20% of total marks) • a final presentation, 10-20 min (30% of total marks) Task-oriented scope of each performance. 75% of the total marks are needed to pass the module.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“
Module Components	• Laboratory: Programming Languages and Techniques for Artificial Intelligence Laboratory
Components to be offered in the Current Semester	No assignment

Module 14441 Bioinformatics Laboratory

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14441	Compulsory elective

Modul Title	**Bioinformatics Laboratory** Praktikum Bioinformatik
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will have acquired practical skills in developing and implementing artificial intelligence and algorithmic approaches to solving bioinformatics problems, in particular: • In-depth understanding of the state-of-the-art in methods of bioinformatics, • Ability to carry out projects (project planning, time management, communication, development tools etc.), • Ability to apply this knowledge and implement the relevant mechanisms, • Ability to collaborate with other developers.
Contents	The laboratory is implemented as one or several study projects. For each project in artificial intelligence and algorithmic approaches to bioinformatics the following work steps have to be accomplished: • Getting acquainted with the state of the art • Project planning • Selecting the models and mechanisms to be used • Implementation of a prototype • Testing and evaluating the prototype • Documentation The course will explicitly discuss ethical and social considerations of machine learning if human data is used.
Recommended Prerequisites	• Knowledge of the content of the module 14336 Introduction to Bioinformatics • Knowledge of Python • basic knowledge of machine learning methods

	• good knowledge of discrete probability theory
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Laboratory training - 2 hours per week per semester Study project - 90 hours Self organised studies - 60 hours
Teaching Materials and Literature	Depending on the projects, the relevant literature or material will be shared in the first session of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Executable and tested prototype (50% of total marks) • Complete documentation, 10-20 pages (20% of total marks) • Successful intermediate presentation of results, 10 min (10% of total marks) • Successful final presentation of results, 20 min (20% of total marks) A student passed the module, if he/she achieves 75% of the total.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400)
Module Components	• Laboratory Bioinformatics
Components to be offered in the Current Semester	**100051** Practical training Laboratory Bioinformatics - 2 Hours per Term

Module 14445 Seminar Computing at Scale in Machine Learning

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14445	Compulsory elective

Modul Title	**Seminar Computing at Scale in Machine Learning** Seminar Computing at Scale im maschinellen Lernen
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	4
Learning Outcome	After successfully completing the module, students will be familiar with state-of-the-art problems and methodological approaches in the intersection of large-scale computing and machine learning; that is, computing at scale for machine learning and machine learning for large-scale computation. They will have the ability to familiarize themselves with current research in the area from original research literature, to participate in a technical discussion within the context of international science, and present scientific content in written and oral form.
Contents	Students will learn about specific state-of-the-art problems and methodological approaches for large-scale computation in machine learning. The topics range from parallel computation on individual machines, to implicit parallelism frameworks on compute clusters, and algorithms and data structures supporting efficient exact or approximate computation with massive data sets in and out of core.
Recommended Prerequisites	• Knowledge of the content of the module 14038 Computing at Scale in Machine Learning: Distributed Computing and Algorithmic Approaches
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 60 hours
Teaching Materials and Literature	Depending on the projects, the relevant literature or material will be shared in the first session of the semester.

Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 30-45 min depending on the subject (40%) • Report on the topic of the seminar presentation, 10 pages (40%) • Active participation (20%) A student passed the module, if he/she achieves 75% of the total.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400)
Module Components	• Seminar Computing at Scale in Machine Learning
Components to be offered in the Current Semester	**100046** Seminar Seminar Computing at Scale in Machine Learning - 2 Hours per Term

Module 14449 Workflows for Machine Learning and Reproducible Science Laboratory

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14449	Compulsory elective

Modul Title	**Workflows for Machine Learning and Reproducible Science Laboratory** Praktikum Workflows für maschinelles Lernen und reproduzierbare Wissenschaft
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	After successfully completing the module, students will have acquired practical skills in developing and implementing machine learning workflows. They will be able to apply state-of-the-art-tools to utilize machine learning for reproducible science through reproducible, replicable, scalable, and portable workflows, related visualization and writing tools, and techniques relevant to implementing GDPR provisions for sensitive data.
Contents	The laboratory is implemented as one or several study projects using workflows for ML and science and related tools. For each project the following work steps have to be accomplished: • Getting acquainted with the state of the art • Project planning • Selecting the models and mechanisms to be used • Implementation of a prototype • Testing and evaluating the prototype • Documentation
Recommended Prerequisites	• Knowledge of the content of the module 14038 Computing at Scale in Machine Learning: Distributed Computing and Algorithmic Approaches • good knowledge of Python and Linux command line • basic knowledge of machine learning methods
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Practical training - 2 hours per week per semester Study project - 90 hours Self organised studies - 60 hours
Teaching Materials and Literature	Depending on the projects, the relevant literature or material will be shared in the first session of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Executable and tested prototype (50% of total marks) • Complete documentation, 10-20 pages (20% of total marks) • Successful intermediate presentation of results, 10 min (10% of total marks) • Successful final presentation of results, 20 min (20% of total marks) A student passed the module, if he/she achieves 75% of the total.
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400)
Module Components	• Laboratory Workflows for Machine Learning and Reproducible Science Laboratory
Components to be offered in the Current Semester	**100042** Practical training Laboratory: Workflows for Machine Learning and Reproducible Science - 2 Hours per Term

Module 14810 Seminar Bioinformatics

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14810	Compulsory elective

Modul Title	**Seminar Bioinformatics** Seminar Bioinformatik
Department	Faculty GW - Faculty of Health Sciences Brandenburg
Responsible Staff Member	Prof. Dr. rer. nat. Schliep, Alexander
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	4
Learning Outcome	After successfully completing the module, students will have acquired the skills needed to use computer science literature in order to familiarize themselves with a new, complex topic. They will be able to present the results, in oral as well as in written form.
Contents	Students learn about specific state-of-the-art problems and methodological approaches used in bioinformatics. The application areas will range from fundamental bioinformatics problems in basic science to applications in medical diagnostics, understanding cellular processes relevant to diagnosis and disease, as well as mechanisms for treating diseases. Methods will include both algorithmic and machine learning approaches.
Recommended Prerequisites	• Solid knowledge in the field of bioinformatics.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 60 hours
Teaching Materials and Literature	Literature references for individual retrieval will be provided at the first class meeting of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 30-45 minutes (40 %) • Written report of the seminar presentation, 10-15 pages (40 %) • Active participation in courses (20 %)

Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories“ • Study programme Informatik M.Sc.: Compulsory elective module in complex „Seminare oder Praktika“ (level 400)
Module Components	• Seminar Bioinformatics
Components to be offered in the Current Semester	No assignment

Module 14895 Advanced Seminar Master Graphic Systems

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14895	Compulsory elective

Modul Title	**Advanced Seminar Master Graphic Systems** Masteroberseminar Graphische Systeme
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successfully completing the module, students will be able to understand, evaluate, and present current topics and research questions in computer science and/or artificial intelligence, as well as develop their own solutions.
Contents	Latest research findings in a complex subfield of artificial intelligence or computer science corresponding to the assigned seminar topic.
Recommended Prerequisites	none
Mandatory Prerequisites	• at least 68 credit points
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	Literature references for individual retrieval will be provided during the first week of the semester, in class and in moodle.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 3-5 seminar presentations, 10-20 minutes each (60 %) • Active participation in class (40 %)
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	20

Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories” • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Seminare oder Praktika" • Study programme Informatik M.Sc.: Compulsory elective module in complex „Seminare oder Praktika" (level 400)
Module Components	• Advanced Seminar Master Graphic Systems
Components to be offered in the Current Semester	**120950** Seminar Advanced Master Seminar Graphic Systems - 2 Hours per Term

Module 14896 Music and Artificial Intelligence

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14896	Compulsory elective

Modul Title	**Music and Artificial Intelligence** Musik und Künstliche Intelligenz
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	4
Learning Outcome	After successfully completing the module, students will have acquired the skills needed to use computer science literature in order to familiarize themselves with a new, complex topic. They will be able to present the results, in oral as well as in written form.
Contents	State of the art in a using modern artificial intelligence methods in the application field of music. This includes, but is not limited to, instrument recognition, song recognition, genre recognition, music composition, and music evaluation.
Recommended Prerequisites	Solid knowledge of the seminar topic.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 60 hours
Teaching Materials and Literature	Literature references for individual retrieval will be provided at the beginning of the seminar.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 30-45 minutes (40 %) • Written report of the seminar presentation, 10-15 pages (40 %) • Active participation in courses (20 %)
Evaluation of Module Examination	Study Performance – ungraded

Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories” • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400)
Module Components	• Seminar Music and Artificial Intelligence
Components to be offered in the Current Semester	**120980** Seminar AI and Music - 2 Hours per Term

Module 14897 Facial Expression Recognition with Deep Learning

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14897	Compulsory elective

Modul Title	**Facial Expression Recognition with Deep Learning** Gesichtsausdruckserkennung mit Deep Learning
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. habil. Cunningham, Douglas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	4
Learning Outcome	After successfully completing the module, students will have acquired the skills needed to use computer science literature in order to familiarize themselves with a new, complex topic of deep learning methods to automatically find faces. They will be able to present the results, in oral as well as in written form.
Contents	State of the art in a using deep learning methods to automatically find faces in an image or video and then process and recognize any facial expressions that may be there.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 60 hours
Teaching Materials and Literature	Literature references for individual retrieval will be provided at the beginning of the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation, 30-45 minutes (40 %) • Written report of the seminar presentation, 10-15 pages (40 %) • Active participation in courses (20 %)
Evaluation of Module Examination	Study Performance – ungraded

Limited Number of Participants	20
Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Seminars or Laboratories” • Study programme Informatik M.Sc.: Compulsory elective module in complex "Seminare oder Praktika" (level 400)
Module Components	• Seminar Facial Expression Recognition with Deep Learning
Components to be offered in the Current Semester	**120970** Seminar Facial Expression Recognition with Deep Learning - 2 Hours per Term

Module 14900 Master Seminar Applied Mathematics

assign to: Seminars or Laboratories

Study programme Artificial Intelligence

Degree	Module Number	Module Form
Master of Science	14900	Compulsory elective

Modul Title	**Master Seminar Applied Mathematics** Masterseminar Angewandte Mathematik
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Breuß, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	4
Learning Outcome	Upon successful completion, students will have in-depth knowledge of artificial intelligence. They will be able to understand, examine, and critically analyze the methods. Students will be able to present their findings. They will have an advanced level of knowledge about fundamental and current research directions in artificial intelligence.
Contents	Topics covered include object detection, object tracking, image segmentation, data sets, autoencoders, dictionary learning and Markov decision processes.
Recommended Prerequisites	none
Mandatory Prerequisites	• at least 60 credt points
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	Literature references will be provided during the first week of lectues.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar presentation (30-45 min) and handout (10-15 pages), depending on the topic (70%) • Active participation in discussions (30%)
Evaluation of Module Examination	Study Performance – ungraded
Limited Number of Participants	none

Remarks	• Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex "Seminars or Laboratories"
Module Components	• Master Seminar Applied Mathematics
Components to be offered in the Current Semester	**130370** Seminar Master Seminar in Artificial Intelligence and Machine Learning - 2 Hours per Term **130371** Seminar Masterseminar in Artificial Intelligence and Image Processing - 2 Hours per Term

Erläuterungen

Das Modulhandbuch bildet als Teil der Prüfungsordnung die Rechtsgrundlage für ein ordnungsgemäßes Studium. Darüber hinaus soll es jedoch auch Orientierung bei der Gestaltung des Studiums geben.

Dieses Modulhandbuch wurde am 17. März 2026 automatisch für den Master (universitär)-Studiengang Artificial Intelligence (universitäres Profil), PO-Version 2022, aus dem Prüfungsverwaltungssystem auf Basis der Prüfungsordnung generiert. Es enthält alle zugeordneten Module einschließlich der ausführlichen Modulbeschreibungen mit Stand vom 17. März 2026. Neben der Zusammensetzung aller Veranstaltungen zu einem Modul wird zusätzlich das Veranstaltungsangebot für das jeweils aktuelle Semester gemäß dem Veranstaltungsverzeichnis der BTU ausgegeben.

The module catalogue is part of the examination regulation and as such establishes the legal basis for studies according to the rules. Furthermore, it should also give orientation for the organisation of the studies.

This module catalogue was generated automatically by the examination administration system on the base of the examination regulation on the 17 March 2026, for the Master (universitär) of Artificial Intelligence (research-oriented profile). The examination version is the 2022, Catalogue contains all allocated modules including the detailed module descriptions from 17 March 2026. Apart from the composition of all components of a module, the list of lectures, seminars and events for the current semester according to the catalogue of lectures of the BTU is displayed.