Friedrich-Alexander-Universität
Erlangen-Nürnberg

Module description

for the degree programme

Bachelor of Science

Artificial Intelligence

(Version of examination regulation: 20242)

for the winter term 2024/2025

Please note:
As the BSc AI starts in the winter semester 24/25, not all modules are offered yet. The modules of the higher semesters will be added over time.

Table of contents

1	**Module name** 47598	**Algorithms, programming, and data representation**	**10 ECTS**
2	Courses / lectures	Vorlesung: Algorithms, programming, and data representation (4 SWS) Übung: Algorithms, programming, and data representation; Computer Exercise (2 SWS) Übung: Algorithms, programming, and data representation; Exercise (2 SWS) No. Lectures will be hybrid and recorded. Tutorials and Q&A will be on the MS Teams Module Lab queue.	5 ECTS 2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr. Bernhard Kainz Christine Müller	

4	**Module coordinator**	Prof. Dr. Bernhard Kainz
5	**Contents**	The lecture Algorithms, programming, and data representation is aimed at students with tech and math background and is one of the basic lectures in the field of computer science. In addition to an introduction to fundamental algorithms, (object-oriented) programming in Python, various data structures such as linked lists, trees and graphs are covered. Algorithms include recursion, sorting methods and graph algorithms, as well as O notation of algorithms. Topics: • Programming and computing basics • Data structures • Object orientation • Python basic knowledge • Computational Complexity • Basic algorithms Students will solve object-oriented programming tasks in the Python programming language illustrate program structures with the help of a subset of the Unified Modelling Language compare the efforts of different algorithms in terms of runtime and memory requirements implement basic combinatorial algorithms, especially search and sort algorithms, binary trees and basic graph algorithms understand and use recursion as a link between mathematical problem descriptions and programming implementation translate recursive problem descriptions into iterative ones plan and process programming tasks in such a way that they are completed on time. Syllabus: (L - lecture, C - coursework, T - tutorial) L01 Motivation and Logistics L02 Introduction: What does a Computer do C01 Explore local Anaconda and Google Colab L03 Data Representation and Boolean Algebra

		L04 Floating Point numbers T01 Organization and Boolean Algebra C02 Number Representations and Boolean Algebra in Python L05 Memory Organisation L06 Branching and Iterations T02 Number Representations and Boolean Algebra C03 Branching and Iterations L07 Decomposition, Abstraction, and Functions, Tuples, Lists, etc. L08 Recursion and Dictionaries T03 Memory Organisation C04 Recursion and Dictionaries L09 Testing, Debugging, Exceptions, and Assertions L10 Object Oriented Programming T04 Decomposition, Abstraction, and Functions C05 Testing, Debugging, Exceptions, and Assertions L11 Classes and Inheritance L12 Program efficency I T05 Recursion C06 Classes and Inheritance L13 Program efficency II L14 Searching and Sorting T06 Object Oriented Programming C07 Searching and Sorting L15 Version management and git L16 API and Libraries T07 Program efficency C08 APIs and Libraries L18 Graphs and graph algorithms L19 Bellman-Ford T08 Searching and Sorting C09 Searching and Sorting L20 Dijkstra L21 Graphs and Trees T09 Graphs and Trees C10 Graphs and Trees L21 Dynamic Programming L22 Hashtables T10 Hashtables C11 Hashtables R01 Revision Q&A R02 Revision Q&A

6	**Learning objectives and skills**	The students will be able to • organize themselves independently into groups and coordinate the organizational and technical process of group work in consultation with each other • communicate and jointly develop solutions for theoretical questions and practical programming tasks within the framework of group tasks • plan and apply targeted measures for mutual quality assurance of the submitted solutions (check each other's group submissions) • jointly take responsibility for the result of their group work, the evaluation of which applies equally to both group partners
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Pflichtmodul Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Tutorial achievement Written examination (120 minutes) Graded examination achievement (Prüfungsleistung): Written examination (120 min) Ungraded course achievement (Studienleistung): weekly submission of exercises; at least 50% of total points required to pass
11	**Grading procedure**	Tutorial achievement (0%) Written examination (100%) Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Guttag JV. Introduction to computation and programming using Python. MIT Press; 2013 Aug 9.

1	**Module name** 93097	**Einführung in das Software Engineering** Introduction to software engineering	**5 ECTS**
2	Courses / lectures	Vorlesung: Introduction to Software Engineering Übung: Introduction to Software Engineering Exercises	- -
3	Lecturers	Sally Zeitler Prof. Dr.-Ing. Andreas Maier	

4	**Module coordinator**	Prof. Dr.-Ing. Andreas Maier
5	**Contents**	• Einführung in die einzelnen Phasen der Softwareentwicklung: Anforderungsanalyse, Spezifikation, Entwurf, Implementierung, Test, WartungProzessmodelle • Prozessmodelle • Agile Softwareentwicklung • Anforderungsanalyse und -verwaltung • Modellierung von Systemen (u.a. mit UML) • Software-Architekturen und Designmuster • Teststrategien • Umgang mit Software-Alterung • Projektmanagement • Software-Engineering im Bereich Machine Learning • Refactoring zur Unterstützung der Wartungsphase
6	**Learning objectives and skills**	Die Studierenden • Beschreiben Prozessmodelle und unterscheiden plangesteuerte (wie das Wasserfall- und V-Modell) und agile Prozessmodelle (wie XP, Scrum, RUP und Kanban) • Erläutern verschiedene Techniken der Anforderungsanalyse und –Ermittlung (wie Endliche Zustandsautomaten, Petri-Netze, Use Cases, User Stories) und wenden diese für plan-gesteuerte und agile Prozesse an • Stellen die Unterschiede zwischen agilem und plan-gesteuertem Requirements-Engineering dar • Verstehen und erläutern UML-Diagramme (wie Use Case-, Klassen-, Sequenz- und Kommunikationsdiagramme) und wenden diese auf praktische Beispiele der Objektorientierung an • Reproduzieren allgemeine Entwurfslösungen wiederkehrender Probleme des Software-Engineerings und wenden diese an • Wenden funktionale und strukturelle Testansätze an • Erklären Methoden zur Änderung und Weiterentwicklung von Software • Beschreiben Ansätze für das Projekt-Management von Softwareprojekten • Erläutern wie Methoden des Maschinellen Lernens für Software-Engineering eingesetzt werden können
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 3

9	**Module compatibility**	Pflichtmodul Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	german
16	**Bibliography**	• Software Engineering, Ian Sommerville, 10. Auflage, 2016 • Software-Engineering Kompakt, Anja Metzner, 2020 • Handbook of Software Engineering, Sungdeok Cha, Richard N. Taylor, Kyochul Kang (Hrsg.), 2019

1	**Module name** 65714	**Mathematics for Data Science 1** Mathematics for data science 1	**10 ECTS**
2	Courses / lectures	Vorlesung: Special Topics in Mathematics for Engineers I (2 SWS) Vorlesung: Mathematics for Engineers I (4 SWS) Übung: Exercise Mathematics for Engineers I (2 SWS)	- - -
3	Lecturers	Dr. Yasmine Sanderson	

4	**Module coordinator**	Prof. Dr. Frauke Liers-Bergmann
5	**Contents**	**Foundations:** • introduction to set theory, natural, rational and real numbers • complex numbers: calculation rules and their geometric interpretation, quadratic equations **Vector spaces:** • Foundations, linear dependence, span, basis, dimension, Euclidean vector space, subspaces, affine spaces **Matrices, linear maps, systems of linear equations:** • Matrix algebra, structure of the solution sets of linear equations, Gauss algorithm, inverse matrix, linear maps, determinants, image and kernel, eigenvalues and eigenvectors, basis, least squares problems **Foundations of real analysis:** • limits, continuity, elementary functions, inverse functions
6	**Learning objectives and skills**	Students will • define and explain elementary basic calculus concepts. • learn basic structures of the number system; handling of vectors and matrices. • apply basic knowledge and techniques in calculus and reproduce fundamental principles. • collect and evaluate relevant information and recognize elementary relationships. • recognize linear relationships and treat them quantitatively and qualitatively. • explain and use solution methods for systems of linear equations. • learn basic knowledge in linear algebra, linear mappings and associated matrix calculations. • learn basic proof techniques in above-mentioned areas.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Pflichtmodul Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Tutorial achievement Written examination (120 minutes) Graded examination achievement (Prüfungsleistung): Written examination (120 min) Ungraded course achievement (Studienleistung): Exercises

11	**Grading procedure**	Tutorial achievement (0%) Written examination (100%) Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: ?? h (keine Angaben zum Arbeitsaufwand in Präsenzzeit hinterlegt) Independent study: ?? h (keine Angaben zum Arbeitsaufwand im Eigenstudium hinterlegt)
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	1) Applied Linear Algebra and Matrix Analysis by Thomas S. Shores, Undergraduate Texts in Mathematics, Springer Verlag. 2) Linear Algebra by M. Thamban Nair and Arindama Singh, Undergraduate Texts in Mathematics, Springer Verlag. 3) Calculus by Jon Rogawski, W. H. Freeman and Company.

1	**Module name** 92405	**Artificial Intelligence Perspectives**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: AI Perspectives (4 SWS)	5 ECTS
3	Lecturers	Jonas Müller Prof. Dr. Björn Eskofier	

4	**Module coordinator**	Prof. Dr. Björn Eskofier
5	**Contents**	The lecture AI Perspectives serves as a weekly platform for experts and decision makers from artificial intelligence, informatics and non-commercial research to give talks on their fields and views for students to not only enhance the engineer's general knowledge, but also to paint an accurate picture of the engineer's work environment in the field of future employers and are introduced to their specific requirements. Apart from a broadened horizon, insights into the interdisciplinary activities and an introduction to the region, the main goal of the event is to transmit motivation and orientation.
6	**Learning objectives and skills**	The students are familiar with possible job profiles of engineers in the field of artificial intelligence and can orientate themselves according to their own career.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Pflichtmodul Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written or oral Graded examination achievement (Prüfungsleistung): Written examination (90 min)
11	**Grading procedure**	Written or oral (100%) Written examination (100 %)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: ?? h (keine Angaben zum Arbeitsaufwand in Präsenzzeit hinterlegt) Independent study: ?? h (keine Angaben zum Arbeitsaufwand im Eigenstudium hinterlegt)
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	The Relevance of Artificial Intelligence in the Digital and Green Transformation of Regional and Local Labour Markets Across Europe - Perspectives on Employment, Training, Placement, and Social Inclusion (https://www.katalog.fau.de/TouchPoint/singleHit.do?methodToCall=showHit&curPos=6&identifier=2_SOLR_SERVER_474630890) Industry 4.0 Perspectives and Applications (https://directory.doabooks.org/handle/20.500.12854/113219)

		Multidisciplinary Perspectives on Artificial Intelligence and the Law (https://link.springer.com/book/10.1007/978-3-031-41264-6)

Application Domain Fundamentals

Students must obtain a total of 20 ECTS in the area of "Application Domain Fundamentals".

Places are allocated centrally. Please do not register directly for the modules, but indicate in an e-mail to study-ai-bachelor@fau.de which courses you would like to take this semester.
As these modules from other degree programs are also kindly offered to BSc AI students, the limited places available in the courses are allocated centrally. Please do not register directly for the courses on your own and do not take the exam if you have not been centrally assigned to a module and have taken part in the course.

1	**Module name** 85603	**Analysis of macroeconomic and financial markets data**	**5 ECTS**
2	Courses / lectures	Seminar: Analysis of Macroeconomic and Financial Markets Data (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Jonas Dovern Dr. Maximilian Böck	

4	**Module coordinator**	Prof. Dr. Jonas Dovern
5	**Contents**	Economic data from businesses, countries, international organizations, and international financial markets are often available as time series. This class covers the basic econometric methods that are used to analyze such data. In particular, this involves analyzing the properties of economic time series, models for trends and seasonal effects, autoregressive moving average (ARMA) models, forecasting, analyzing statistical features of financial market data, and (G)ARCH models.
6	**Learning objectives and skills**	Students are able to ... • visualize time series and to identify features such as trends or seasonal patterns; • analyze time series using ADL, ARMA and (G)ARCH models (specification, estimation, forecasting); • produce, interpret and evaluate time-series forecasts; • practically analyze data from various countries or international financial markets using the software R and to interpret regression outputs from the statistical software.
7	**Prerequisites**	Recommendation: Data Science: Datenauswertung and Data Science: Statistik / Statistics; Data Science: Ökonometrie / Introduction to Econometrics
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written assignment/Seminar paper Registration for the examination (project report) is only possible in the winter term! During summer terms, we offer only examination for students who failed to pass in the winter term!
11	**Grading procedure**	Written assignment/Seminar paper (100%) Students can improve their overall grade by successfully completing a number of online quizzes during the semester.
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Diebold, F. X. (2007), Elements of Forecasting, 4th edition (or earlier editions), Thomson Higher Education, Mason.

		Verbeek, M. (2004), A Guide to Modern Econometrics, 2nd edition, John Wiley & Sons. Wooldrige, J. M. (2015). Introductory Econometrics. A Modern Approach, 6th edition (or other editions), Cengage Learning.

1	**Module name** 96010	**Architekturen der digitalen Signalverarbeitung** Architectures for digital signal processing	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Georg Fischer
5	**Contents**	Inhalt: • Basis-Algorithmen der Signalverarbeitung (FFT, Fensterung, Digitale FIR- und IIR-Filter) • Nichtideale Effekte bei Digitalfiltern (Quantisierung der Filterkoeffizienten, Quantisierte Arithmetik) • CORDIC-Architekturen • Architekturen für Multiratensysteme (Abtastratenumsetzer) • Architekturen digitaler Signalgeneratoren • Maßnahmen zur Leistungssteigerung (Pipelining) • Architekturen digitaler Signalprozessoren • Anwendungen Content: • Basic algorithms of signal processing (FFT, windowing, digital FIR and IIR-filters) • Non-idealities of digital filters (quantization of filter coefficients, fixed-point arthmetic) • CORDIC-architectures • Architectures of systems with multiple sampling rates (conversion between different sampling rates) • Digital signal generation • Measures of performance improvement (pipelining) • Architecture of digital signal processors • Applications
6	**Learning objectives and skills**	Die Studierenden erlangen Grundlagenkenntnisse der Signaltheorie und können zeit- und wertkontinuierliche sowie zeit- und wertdiskrete Signale im Zeit- und Frequenzbereich definieren und erklären Die Studierenden sind in der Lage, ein klassisches Echtzeitsystem zur digitalen Signalverarbeitung konzeptionieren und die Einzelkomponenten nach den Anforderungen zu dimensionieren Die Studierenden erlangen einen Überblick über Vor- und Nachteile analoger sowie digitaler Signalverarbeitung Die Studierenden verstehen die Theorie der Fourier-Transformation und sind in der Lage, die Vorteile der Fast-Fourier-Transformation in der digitalen Signalverarbeitung zu verstehen und anzuwenden Die Studierenden können digitale Filter dimensionieren und beurteilen ===Englisch=== Students

		• can obtain fundamentals of signal theory and can define as well time-comtinous and value-continous as time-discrete and value-discrete signals in time and frequency domain • can construct a realtime digital signal processing system and dimension its components according requirements • can review pros and cons of analogue versus digitzal signal processing • can apply fourier transformation and illustrate the advantages of fast fourier transformation in the context of digital signal processing • can dimension digital filters and evaluate their performance
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Electronic examination (60 minutes)
11	**Grading procedure**	Electronic examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 87017	**Data Collection Methods in the Social and Behavioral Sciences** Data collection methods in the social and behavioral sciences	**5 ECTS**
2	Courses / lectures	Tutorium: Tutorium zum VHB-Kurs "Data Collection Methods in the Social and Behavioral Sciences" (0 SWS) Kurs: VHB-Kurs "Data Collection Methods in the Social and Behavioral Sciences" (2 SWS)	- -
3	Lecturers	Dr. Karen Döring Prof. Dr. Klaus Moser	

4	**Module coordinator**	Prof. Dr. Klaus Moser
5	**Contents**	This course presents an overview of various data collection methods in the Social and Behavioral Sciences that are particularly relevant for Organizational Behavior, Consumer Behavior, and Experimental Economics, but also for the Health Sciences and Business Research. First, students learn some basics on reasons for collecting data, research designs (e.g., experiments, longitudinal studies), media (paper & pencil, reaction data, web etc.), targets (e.g., individuals, groups, organizations), and the quality of measures and data (e.g., objectivity, reliability, validity). The main part will be the presentation of data collection methods, for example observation of behavior, interviews, simulations, ratings and judgments, psychological tests (personality, competencies, intelligence, recall and recognition tests), physiological measures (e.g., skin conductance, magnetic resonance imaging), and non-reactive measures (e.g., analyzing tracking, website contents). The final part will cover basics on ethical and legal issues.
6	**Learning objectives and skills**	Students will gain an overview of methods as well as learn how to find and evaluate them. In addition, they will have some experiences with using them. One important aim is to prepare students for working on a thesis in which the collection and/or evaluation of primary data on individuals, groups, or organizations plays an important role.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement Written examination with multiple choice
11	**Grading procedure**	Seminar achievement (50%) Written examination with multiple choice (50%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 0 h Independent study: 150 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	Hoyer, W.D., MacInnis, D.J. & Pieters, R. (2016). *Consumer behavior*. Cengage Learning. (Chapter: Developing information about consumer behavior.) Bryman, A. (2016). *Social Research Methods*. Oxford: University Press.

1	**Module name** 87005	**Electronic Human Resource Management (e-HRM)** Electronic human resource management (e-HRM)	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Electronic Human Resources Management (E-HRM) (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Sven Laumer Tina Wölfl	

4	**Module coordinator**	Prof. Dr. Sven Laumer Tina Wölfl
5	**Contents**	This course focuses on the use and development of digital technologies for the management of human resources in an organizational context. The lecture and the content provided will address theories, methods and digital technologies and provide students with the necessary knowledge for the identification ("discovery"), design ("development"), diffusion ("diffusion") and evaluation ("impact") of digital innovations in human resources management. This phase of knowledge transfer uses an e-learning module, which combines different media. In the context of the application of the knowledge transferred, students are instructed to lead discussions on exercises or case studies. For this purpose, problems from the practice of human resources work are described and students should discuss them with the theories and methods presented or develop suggestions for the use of digital technologies. In the context of knowledge implementation, students are accompanied by a case study analysis to apply the theories and methods. In the virtual design, the case study of the FAUBank will be used in the course for this purpose.
6	**Learning objectives and skills**	The general learning and qualification objective of the module is to enable students to gain knowledge about the use and development of digital technologies in human resources management, to explain the effects of digital technologies on human resources management (HRM) and to design digital innovations for HRM.
7	**Prerequisites**	English language proficiency (C1) (for the course completion in English) Registration via the vhb (www.vhb.org) is mandatory in order to take the course and to gain access to the StudOn course.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 1 h Independent study: 149 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	german or english
16	**Bibliography**	Will be announced during the course

1	**Module name** 92776	**Fundamentals of electrical engineering**	**5 ECTS**
2	Courses / lectures	Vorlesung: Fundamentals of Electrical Engineering (dummy for asynchronous, non-supervised course) (2 SWS)	5 ECTS
3	Lecturers	Hans Rosenberger	

4	**Module coordinator**	Prof. Dr.-Ing. Ralf Müller
5	**Contents**	• Elektrostatisches Feld • Stationäres elektrisches Strömungsfeld • Gleichstromnetzwerke • Stationäres Magnetfeld • Zeitlich veränderliches elektromagnetisches Feld • Zeitlich periodische Vorgänge • Ausgleichsvorgänge • Halbleiterbauelemente und ausgewählte Grundschaltungen ==== • Electrostatic field • Stationary electric flow field • Direct current networks • Stationary magnetic field • Time-varying electromagnetic field • Time periodic processes • Transient processes • Semiconductor devices and selected basic circuits
6	**Learning objectives and skills**	• Die Studierenden erläutern die Grundkonzepte von elektrische Ladung und Ladungsverteilungen. Sie nutzen das Coulombsche Gesetz und analysieren die elektrische Feldstärke, berechnen das elektrostatisches Potential und die elektrische Spannung. Sie bestimmen die elektrische Flussdichte und wenden das Gaußsche Gesetz an. Die Studierenden beschreiben Randbedingungen der Feldgrößen und bestimmen den Einfluss von Materie im elektrostatischen Feld. Sie bestimmen die relevanten Größen an Kondensator und Kapazität und ermitteln den Energiegehalt des elektrischen Feldes. • Die Studierenden erläutern die Begriffe Strom und Stromdichte, sie verwenden das Ohmsche Gesetz und erläutern das Verhalten an Grenzflächen. Sie ermitteln Energie und Leistung. • Die Studierenden erläutern die Rolle von Spannungs- und Stromquellen in Gleichstromnetze. Mit Hilfe der Kirchhoffsche Gleichungen analysieren sie einfache Widerstandsnetzwerke, die Wechselwirkung zwischen Quelle und Verbraucher und allgemeine Netzwerke. • Die Studierenden erklären die Begriffe Magnetfeld und Magnete. Sie berechnen die im Magnetfeld auf bewegte Ladungen wirkenden Kräfte und die magnetische Feldstärke

durch Nutzung des Durchflutungsgesetzes. Die Studierenden erläutern die magnetischen Eigenschaften der Materie und das Verhalten der Feldgrößen an Grenzflächen. Sie ermitteln die Induktivität.

- Die Studierenden nutzen das Induktionsgesetz, bestimmen die Selbstinduktion, analysieren einfache Induktivitätsnetzwerke und ermitteln die Gegeninduktivität. Sie analysieren den Energieinhalt des magnetischen Feldes, wenden die Prinzipien der Bewegungsinduktion (Generatorprinzip) und der Ruheinduktion (Übertrager) an.
- Die Studierenden erläutern die Beziehungen zeitlich veränderlicher Ströme und Spannungen. Sie verwenden Methoden der komplexen Wechselstromrechnung um Wechselspannungen und Wechselströme zu ermitteln. Sie ermitteln und analysieren die Übertragungsfunktionen linearer zeitinvarianter Systeme. Sie analysieren Leistung und Energie in Wechselspannungsnetzen.
- Die Studierenden analysieren lineare, zeitinvariante Systeme sowie Signale in Zeit- und Frequenzbereich (Fourieranalyse). Dazu bestimmen und analysieren sie die Eigenfunktionen von LTI-Systemen und deren Übertragungsfunktionen und untersuchen Schaltungen aus LTI-Systemen.
- Die Studierenden erläutern die Grundlagen von Ausgleichsvorgängen in einfachen Netzwerken und berechnen diese bei der R-L-Reihenschaltung. Sie erläutern divergierende Fälle und untersuchen Netzwerke mit einem Energiespeicher mit Hilfe einer vereinfachten Analyse.
- Die Studierenden erläutern den Ladungstransport in Halbleitern und analysieren den pn-Übergang. Sie ermitteln Ströme und Spannungen bei den folgenden Halbleiterbauelementen: Halbleiterdiode, Z-Diode, Bipolartransistor, Feldeffekttransistor Thyristor, IG-Bipolar-Transistor.
- Die Studierenden wenden alle eingeführten Inhalte an, um selbständig einfache und dabei dennoch möglichst praxisnahe kleine Probleme systematisch zu lösen. Sie kontrollieren dabei selbst ihren Lernfortschritt und besprechen Fragen mit einem Tutoren, woraus sich Fachgespräche entwickeln, wie sie die ähnlich später in Verhandlungen und bei der Produktentwicklung mit Fachingenieurinnen und Fachingenieuren aus Elektro- und Informationstechnik führen müssen, sowie im interdisziplinären Dialog mit Elektro- und Informationstechnikern und Physikern.
- Die Studierenden erkennen die Vorzüge einer regelmäßigen Nachbereitung und Vertiefung des Stoffes, da sie in diesem Modul ein für ihr Fachstudium fremdes Gebiet kennenlernen mit einer teilweise anderen mathematischen und physikalischen Herangehensweise. Sie zeigen eine hohe

Arbeitsdisziplin, Freude am Entdecken von Neuem, aber auch eine gewisse Belastbarkeit und Leistungsbereitschaft.

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- Students explain the basic concepts of electric charge and charge distributions. They use Coulomb's law and analyze the electric field strength, calculate the electrostatic potential and the electric voltage. They determine electric flux density and apply Gauss's law. Students describe boundary conditions of field quantities and determine the influence of matter in the electrostatic field. They determine the relevant quantities at the capacitor and capacitance and determine the energy content of the electric field.
- The students explain the terms current and current density, they use Ohm's law and explain the behavior at boundaries. They determine energy and power.
- Students explain the role of voltage and current sources in DC power systems. Using Kirchhoff's equations, they analyze simple resistor networks, the interaction between source and load, and general networks.
- Students explain the terms magnetic field and magnets. They calculate the
- forces acting on moving charges in the magnetic field and the magnetic field strength by using the law of flux. Students explain the magnetic properties of matter and the behavior of field quantities at boundaries. They determine inductance.
- Students use the law of induction, determine self-inductance, analyze simple inductance networks, and determine mutual inductance. They analyze the energy content of the magnetic field, apply the principles of motion induction (generator principle) and rest induction (transformer).
- Students explain the relationships of time-varying currents and voltages. They use methods of complex numbers in AC curcuits to determine alternating voltages and alternating currents. They determine and analyze the transfer functions of linear time-invariant systems. They analyze power and energy in AC power systems.
- Students analyze linear, time-invariant systems as well as signals in time and frequency domain (Fourier analysis). For this purpose, they determine and analyze the eigenfunctions of LTI systems and their transfer functions and examine circuits from LTI systems.
- The students explain the basics of transient processes in simple networks and calculate them for the R-L series circuit. They explain divergent cases and investigate networks with an energy storage using a simplified analysis.
- Students explain charge transport in semiconductors and analyze the pn junction. They determine currents and voltages for the following semiconductor devices: Semiconductor diode,

		Z-diode, bipolar transistor, field effect transistor thyristor, IG bipolar transistor. • The students apply all introduced contents to independently and systematically solve simple and yet practical small problems. They control their learning progress themselves and discuss questions with a tutor, from which technical discussions develop, as they later have to conduct them similarly in negotiations and product development with specialist engineers from electrical and information engineering, as well as in interdisciplinary dialog with electrical and information engineers and physicists. • Students recognize the benefits of regular follow-up and consolidation of the material, since in this module they become acquainted with an area that is unfamiliar to their specialized studies, with a partially different mathematical and physical approach. They show a high level of work discipline, enjoy discovering new things, but also a certain resilience and willingness to perform.
7	**Prerequisites**	The students use methods of vector analysis and use Cartesian coordinates, cylindrical and polar coordinates. They solve systems of linear equations and calculate with complex numbers. They use the trigonometric formulas and solve linear ordinary differential equations with constant coefficients in transient processes. Students know and understand basic physical concepts, especially quantities and quantity equations.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Manuskript zur Vorlesung / Lecture notes • ALBACH, M.: Elektrotechnik, 1. Auflage, Pearson-Studium, München, 2011. • ALBACH, M., FISCHER, J.: Übungsbuch Elektrotechnik, 1. Auflage, Pearson-Studium, München, 2012. • FROHNE, H. et al.: Moeller Grundlagen der Elektrotechnik, 22., verbesserte Auflage, Vieweg+Teubner Verlag, Wiesbaden, 2011.

		• SPECOVIUS, J.: Grundkurs Leistungselektronik: Bauelemente, Schaltungen und Systeme , 4. Auflage, Vieweg +Teubner, Wiesbaden, 2010.

1	**Module name** 97123	**Integrated Production Systems** Integrated production systems	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Integrated Production Systems (vhb) (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr.-Ing. Jörg Franke Bernd Hofmann	

4	**Module coordinator**	Prof. Dr.-Ing. Jörg Franke
5	**Contents**	• Concepts and Success Factors of Holistic Production Systems • Production organization in the course of time • The Lean Production Principle (Toyota Production System) • The 7 Types of Waste (Muda) in Lean Production • Visual management as a control and management instrument • Demand smoothing as the basis for stable processes • Process synchronization as the basis for capacity utilization • Kanban for autonomous material control according to the pull principle • Empowerment and group work • Lean Automation - "Autonomation" • Fail-safe operation through Poka Yoke • Total Productive Maintenance • Value stream analysis and value stream design • Workplace optimization (lean manufacturing cells, U-Shape, Cardboard Engineering) • OEE analyses to increase the degree of utilization • Quick Setup (SMED) • Implementation and management of the continuous improvement process (CIP, Kaizen) • Overview of quality management systems (e.g. Six Sigma, TQM, EFQM, ISO9000/TS16949) and analysis tools for process analysis and improvement (DMAIC, Taguchi, Ishikawa) • administrative waste • Specific design of the TPS (e.g. for flexible small-batch production) and adapted implementation of selected international corporations
6	**Learning objectives and skills**	After successfully attending the course, students should be able to • Understand the importance of holistic production systems; • Understand and evaluate Lean Principles in their context; • to evaluate, select and optimise the necessary methods and tools; • To be able to carry out simple projects for the optimisation of production and logistics on the basis of what has been learned in a team.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1

9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 94920	**International Supply Chain Management** International supply chain management	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: International Supply Chain Management (vhb) (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr.-Ing. Jörg Franke Simon Schlichte	

4	**Module coordinator**	Prof. Dr.-Ing. Jörg Franke
5	**Contents**	Contents: The virtual course intents to give an overview on the main tasks of a supply chain manager in an international working environment: • Goals and tasks • Methods and tools • International environment • Knowledge and experience of industrial practice • Cutting edge research on SCM For practical training, 3 additional Case Studies are executed as part of the course. Lehreinheiten / Units: • Integrated logistics, procurement, materials management and production • Material inventory and material requirements in the enterprise • Strategic procurement • Management of procurement and purchasing • In-plant material flow and production systems • Distribution logistics, global tracking and tracing • Modes of transport in international logistics • Disposal logistics • Logistics controlling • Network design in supply chains • Global logistic structures and supply chains • IT systems in supply chain management • Sustainable supply chain management
6	**Learning objectives and skills**	After having completed this course successfully, the student will be able to • define the basic terms of supply chain management • understand important procurement methods and strategies • name and classify different stock types and strategies • analyse possibilities for cost reduction in supply chains • know and differentiate central IT systems of supply chain management • explain disposal and controlling strategies • recognise the main issues in international supply networks • know the possibilities of transformation to a sustainable supply chain • assess different modes of transport
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1

9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (120 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 122337	**Magnetic Resonance Imaging** Magnetic resonance imaging	**5 ECTS**
2	Courses / lectures	Übung: Magnetic Resonance Imaging 1 - Übung (2 SWS) Vorlesung: Magnetic Resonance Imaging 1 (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr.-Ing. Andreas Maier Prof. Dr. Armin Michael Nagel Prof. Dr. Frederik Bernd Laun	

4	**Module coordinator**	Prof. Dr. Frederik Bernd Laun Prof. Dr.-Ing. Andreas Maier
5	**Contents**	In this module,the physical and technical basics of MRI are taught in detail. The principles of data acquisition are explained and various examples are shown. Imperfections in the data acquisition lead to image artifacts that cannot be avoided in all cases. Strategies for detecting and avoiding image artifacts are explained. One of the great strengths of MRI in medical diagnostics is the ability to acquire images with different contrasts. The origin of the frequently used T1 and T2 weighted image contrasts is discussed in detail. Various MRI sequence techniques are also discussed."
6	**Learning objectives and skills**	The participants • understand the principles, properties and limits of basic MRI techniques • develop the ability to choose an appropriate basic MRI sequence and to set up the corresponding sequence parameters for a range of basic applications • are able to explain MRI techniques, algorithms and concepts of the lecture to other engineers.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (120 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 568977	**Magnetic Resonance Imaging 2 + Übung** Magnetic resonance imaging 2 + exercise	**5 ECTS**
2	Courses / lectures	Vorlesung: Magnetic Resonance Imaging 2 (2 SWS)	2,5 ECTS
3	Lecturers	Prof. Dr. Frederik Bernd Laun Prof. Dr. Armin Michael Nagel Prof. Dr.-Ing. Andreas Maier	

4	**Module coordinator**	Prof. Dr. Frederik Bernd Laun Prof. Dr.-Ing. Andreas Maier
5	**Contents**	In der Vorlesung werden fortgeschrittene Techniken der Magnetresonanztomographie (MRT) erklärt. Vorausgesetzt werden Kenntnisse über Grundlagen des Gebietes, wie sie z.B. in der Vorlesung Magnetic resonance imaging 1" behandelt werden (Blochgleichungen, T1- und T2-Wichtung, Schichtselektion, k-Raum-Kodierung). U.a. folgende Themen werden behandelt: Echoplanare Bildgebung; Bildgebung des Flusses, der Perfusion, der Diffusion, der magnetischen Suszeptibilität; funktionelle MRT; Ultrahochfeld-MRT; CEST-Bildgebung; MRT-Technik; Beschleunigungsverfahren, z.B. parallele Bildgebung; Angiographie; Bewegungskompensation. The lecture covers advanced topics in magnetic resonance imaging (MRI). Knowledge about the basic principles of MRI are required as they are covered in the lecture Magnetic Resonance Imaging 1" (Bloch equations, T1 and T2 weighting, slice selection, k-space encoding). I.a. the following topics will be treated: echo planar imaging; imaging of flow, perfusion, diffusion, magnetic susceptibility; functional MRI; ultrahigh field MRI; chemical exchange saturation transfer imaging; MRI technique; acceleration methods, e.g. parallel imaging; angiography; motion compensation.
6	**Learning objectives and skills**	The participants • understand the principles, properties and limits of advanced MRI techniques • develop the ability to adapt basic principles of MRI to advanced MRI techniques • are able to explain MRI techniques, algorithms and concepts of the lecture to other engineers.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (120 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 47663	**Magnetic Resonance Imaging sequence programming [MRIpulseq]** Magnetic resonance imaging sequence programming [MRIpulseq]	**5 ECTS**
2	Courses / lectures	Seminar: Magnetic Resonance Imaging sequence programming [MRIpulseq] (0 SWS)	5 ECTS
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Moritz Zaiß
5	**Contents**	In this module in a two-week block course format, the basics of MR sequence programming are taught. Basic sequences such as FID, spin echo, and gradient echo are programmed in Python by the students themselves in this exercise. In addition, the basic image reconstruction based on the simulated and recorded data is written and carried out in Python, including radial imaging and iterative reconstruction. The sequences are created in a format that can be interpreted directly by MR scanners (https://pulseq.github.io). Part of the exercise will therefore be to use the created sequences on a real MRT machine in the Center for Medical Physics and Technology Generate signals from objects and test persons and reconstruct them into MRI images. Basic knowledge of Python is helpful, but can also be acquired in the exercise. The prerequisite for the exercise is knowledge of the Magnetic Resonance Imaging 1 [MRI1] lecture by Prof. Dr. Laun. For participation in the module, including an exercise with written report and demonstration in the following week, a total of 5 ECTS points with grade are given.
6	**Learning objectives and skills**	Students can create sequences in a format that can be interpreted directly by MR scanners (https://pulseq.github.io). In the exercise, they will use the created sequences on a real MRT machine in the Center for Medical Physics and Technology, generate signals from objects and test persons and reconstruct them into MRI images.
7	**Prerequisites**	Voraussetzung für die Übung sind Kenntnisse entsprechend der Vorlesung Magnetic Resonance Imaging 1 [MRI1] von Prof. Dr. Laun. Auskunft: moritz.zaiss@uk-erlangen.de
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable Portfolio exam: exercise with written report and demonstration in the following week
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h

14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	https://www.studon.fau.de/studon/goto.php?target=crs_2819947 https://pulseq.github.io

1	**Module name** 57134	**People Analytics – Data Science für Human Resources Management** People analytics – Data science for human resources management	**5 ECTS**
2	Courses / lectures	Vorlesung: People Analytics (4 SWS) People Analytics is organized as a self-study course. People Analytics ist als Selbstlernkurs organisiert.	5 ECTS
3	Lecturers	Prof. Dr. Sven Laumer	

4	**Module coordinator**	Prof. Dr. Sven Laumer
5	**Contents**	Decision-making is a critical task for HR departments. They not only must handle the onboarding and offboarding of an employee, but are also responsible for optimizing each stage of the employee life cycle and all the processes related to it. Hence, HR experts seek the help of precise data to determine the best course of action. In small companies, information can be easily collected and organized; however, as companies grow, and their number of employee increases, the challenges of managing a larger workforce begins to surface. Thankfully, technological advancements have brought a new set of tools that HR experts can use to aid their decision making. With the right implementation, companies can measure the effectiveness of their business strategies, optimize resources, and improve the employee experience. In this context, People Analytics is a new concept that has been established in science and in practice, which comprises of the processes of collecting, analyzing, and reporting relevant HR information to make data-driven decisions. The lecture videos are pre-recorded and available via StudOn, but make sure to register via https://kurse.vhb.org/ first. Die Entscheidungsfindung ist eine wichtige Aufgabe für Personalabteilungen. Sie müssen sich nicht nur um das Onboarding und Offboarding eines Mitarbeiters kümmern, sondern sind auch für die Optimierung jeder Phase des Mitarbeiterlebenszyklus und aller damit verbundenen Prozesse verantwortlich. Daher sind die Personalverantwortlichen auf präzise Daten angewiesen, um die beste Vorgehensweise zu bestimmen. In kleinen Unternehmen können Informationen leicht gesammelt und organisiert werden. Wenn das Unternehmen jedoch wächst und die Zahl der Mitarbeiter zunimmt, werden die Herausforderungen der Verwaltung einer größeren Belegschaft immer größer. Glücklicherweise hat der technologische Fortschritt eine Reihe neuer Instrumente hervorgebracht, die HR-Experten bei der Entscheidungsfindung helfen können. Mit der richtigen Implementierung können Unternehmen die Effektivität ihrer Geschäftsstrategien messen, Ressourcen optimieren und die Erfahrungen ihrer Mitarbeiter verbessern. In diesem Zusammenhang ist People Analytics ein neues Konzept, das sich in der Wissenschaft und in der Praxis etabliert hat. Es umfasst die Prozesse der Sammlung,

		Analyse und Berichterstattung relevanter HR-Informationen, um datengestützte Entscheidungen zu treffen. Die Vorlesungsvideos sind voraufgezeichnet und über StudOn verfügbar. Bitte melden Sie sich vorher über die https://kurse.vhb.org/ an.
6	**Learning objectives and skills**	Students should be able to discuss why People Analytics is an important concept in the context of Human Resource Management, and differentiate between the different pillars of PA. Furthermore, they should be able to independently implement a People Analytics projects. Die Studierenden sollen erörtern können, warum People Analytics ein wichtiges Konzept im Kontext des Human Resource Managements ist, und die verschiedenen Säulen von PA unterscheiden können. Darüber hinaus sollen sie in der Lage sein, selbstständig ein People Analytics Projekt durchzuführen.
7	**Prerequisites**	• Students should have a basic familiarity with data mining and data analytics methods and tools. • Some elementary knowledge of programming in Python and R is recommended. • Die Studierenden sollten mit den Methoden und Werkzeugen des Data Mining und der Datenanalyse grundlegend vertraut sein. • Grundlegende Kenntnisse der Programmierung in Python und R werden empfohlen.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written In this course, students will be evaluated via a project report, where they are expected to answer theoretical research questions with regard to the People Analytics pillars introduced in the second part of the lecture. Furthermore, students are also expected to implement their own data-driven solutions for each of the research questions. Case studies introduced in the lectures serve as a good guidance for this task. In diesem Kurs werden die Studenten anhand eines Projektberichts bewertet, in dem sie theoretische Forschungsfragen in Bezug auf die im zweiten Teil der Vorlesung vorgestellten Säulen der People Analytics beantworten sollen. Darüber hinaus wird von den Studierenden erwartet, dass sie ihre eigenen datengesteuerten Lösungen für jede der Forschungsfragen implementieren. Die in den Vorlesungen vorgestellten Fallstudien dienen als gute Anleitung für diese Aufgabe.
11	**Grading procedure**	Written (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 0 h Independent study: 150 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	german german or english english
16	**Bibliography**	All relevant material will be provided in StudOn. Alle relevanten Materialien werden in StudOn zur Verfügung gestellt.

1	**Module name** 62766	**Physics I**	**5 ECTS**
2	Courses / lectures	Vorlesung: Physics I (Clean Energy Processes) (3 SWS) Übung: Physics I (Clean Energy Processes, Exercise Class) (2 SWS)	- -
3	Lecturers	Dr. Angela Montanaro Prof. Dr. Daniele Fausti	

4	**Module coordinator**	Prof. Dr. Christopher van Eldik
5	**Contents**	**Mechanics:** • Measurements, units, dimensions, magnitudes • Motion in one spatial dimension • Motion in three spatial dimensions • Newton's laws and concept of forces • Work, energy, power • Centre of gravity, momentum, impact processes • Rotational motion • Law of gravity • Mechanics of deformable bodies, liquids, gases **Oscillations and waves:** • Undamped, damped and forced oscillations • Superposition • Wave propagation • Diffraction • Geometrical optics **Thermodynamics:** • Temperature, ideal gas • Kinetic theory of gases • Real gas, phase diagram • Heat capacity, melting, evaporation energy • Thermal conductivity, thermal radiation • Heat engines, conversion efficiency
6	**Learning objectives and skills**	The students • can explain basics of mechanics and thermodynamics • have a basic understanding of how natural processes can be traced back to fundamental natural laws • apply the acquired knowledge to special situations and questions in mechanics and thermodynamics • have basic competence in analytical thinking as a means of describing scientific relationships accurately
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (90 minutes)

11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Halliday & Resnick's Principles of Physics (Wiley)

1	**Module name** 62768	**Physics II**	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Christopher van Eldik
5	**Contents**	**Electrodynamics:** • Electrostatics • Electrical current, voltage, resistance • Magnetostatics • Electrodynamics **Modern Physics:** • Quantum properties of light • Quantum mechanics • Atomic physics • Solid state physics • Nuclear and particle physics
6	**Learning objectives and skills**	The students • can explain basics of electrodynamics and modern physics • have a basic understanding of how natural processes can be traced back to fundamental natural laws • apply the acquired knowledge to special situations and questions in electrodynamics and modern physics • have basic competence in analytical thinking as a means of describing scientific relationships accurately
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Halliday & Resnick's Principles of Physics (Wiley)

1	**Module name** 92772	**Renewable energies**	**5 ECTS**
2	Courses / lectures	Vorlesung: Renewable Energies (2 SWS) Übung: Renewable Energies (tutorial) (2 SWS)	- -
3	Lecturers	Prof. Dr.-Ing. Jürgen Karl Dr.-Ing. Peter Treiber Prof. Dr. Katharina Herkendell Arkya Sanyal	

4	**Module coordinator**	Prof. Dr.-Ing. Jürgen Karl
5	**Contents**	• Climate change and energy transition • Renewable electricity generation and transmission • Wind energy • Photovoltaics • Bioenergy • Geothermal energy • Hydropower • Heat and electricity storage • Sector coupling and system integration
6	**Learning objectives and skills**	Students who participate in this course will become familiar with basic concepts of conventional energies. Students who successfully participate in this module will • know the fundamentals of renewable energy conversion processes • assess environmental and social aspects of renewable energy conversion.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Application Domain Fundamentals Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 45 h Independent study: 105 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Slides published via StudOn • Karl; Dezentrale Energiesysteme; Oldenbourg-Verlag • Sterner, Stadler; Energiespeicher - Bedarf, Technologien, Integration; Springer Verlag

		• Quaschning; Regenerative Energiesysteme: Technologie - Berechnung Simulation; Carl Hanser Verlag

Artificial Intelligence Electives

Students must obtain a total of 30 ECTS in the area of "AI Electives".

1	**Module name** 47679	**Advanced Upper-Limb Prosthetics** Advanced upper-limb prosthetics	**5 ECTS**
2	Courses / lectures	Vorlesung: Upper-Limb Prosthetics, Theory (2 SWS) Übung: Upper-Limb Prosthetics, Exercises (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr. Claudio Castellini Dr. rer. nat. Sabine Thürauf	

4	**Module coordinator**	Prof. Dr. Claudio Castellini
5	**Contents**	• Introduction to upper-limb prosthetics (ULPs): background, motivation, body- vs. self-powered; state of the art • ULPs as robotic arms: challenges and open questions • Human-machine interfaces for ULPs • Sensor modalities: surface electromyography and more • Intent detection for ULPs: reliability, dexterity, pattern recognition, incrementality, interactive machine learning • Feedback and sensory substitution • Human-Machine Interaction in ULPs • Designing ULP experiments • The clinical perspective: impacting on the amputees everyday life In the exercises, problems will be solved by working out code.
6	**Learning objectives and skills**	Students who have completed the module • have a broad understanding of ULPs • can conceive and design an intent-detection + feedback system for ULPs, given a set of requirements / specifications • have knowledge about the clinical situation in the world of ULPs • can tackle previously unknown problems
7	**Prerequisites**	• basic maths, especially statistics • fundamentals of signal processing and machine learning • mid-level programming (|Python|, |C#| or similar) • fundamentals of experimental psychology
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable (60 minutes) Written examination (60 min)
11	**Grading procedure**	Variable (100%) Written examination (100 %)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english

16	**Bibliography**	• *[2002]* |Control of Multifunctional Prosthetic Hands by Processing the Electromyographic Signal|, M. Zecca, S. Micera, M. C. Carrozza and P. Dario. • *[2010]* |Control of Hand Prostheses Using Peripheral Information|, S. Micera, J. Carpaneto and S. Raspopović. • *[2011]* |Electromyogram pattern recognition for control of powered upper-limb prostheses: State of the art and challenges for clinical use|, E. Scheme and K. Englehart. • *[2012]* |Control of Upper Limb Prostheses: Terminology and Proportional Myoelectric ControlA Review|, A. Fougner, Ø. Stavdahl, P. J. Kyberd, Y. G. Losier and P. A. Parker. • *[2015]* |A survey of sensor fusion methods in wearable robotics|, D. Novak and R. Riener • *[2016]* |Incremental Learning of Muscle Synergies: From Calibration to Interaction|, C. Castellini. • *[2016]* |New developments in prosthetic arm systems|, I. Vujaklija, D. Farina and O.C. Aszmann. • *[2019]* |Upper-limb active prosthetics: an overview|, C. Castellini.

1	**Module name** 93101	**AI in medical robotics**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: AI in Medical Robotics (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Franziska Mathis-Ullrich Dr.-Ing. Christian-Peter Kunz	

4	**Module coordinator**	Prof. Dr. Franziska Mathis-Ullrich
5	**Contents**	This module is concerned with artificial intelligence technologies in medical robotics and with methods that establish different forms of intelligence in medical robotic systems. Participants will become familiar with the design and application of AI methods and algorithms for perception, motor control, planning, cognition and learning and with their application in biorobotic systems and robotic solutions for diagnosis and treatment. Application domains include minimally invasive surgery, motor rehabilitation, exoskeletons and assistive devices, as well as medical service robotics. The taught methods will be applied to application data during designated computer exercises that are integrated into the course. Topics include, but are not limited to: • Basic principles and classification of artificial intelligence • Overview of AI methods and technologies in medical imaging • Implications of surgical workflow planning using AI methods • Motion planning in robotic surgery, rehabilitation robots and medical service robots • Perception in robotic surgery, rehabilitation robots and assistive robots • Motion planning in robotic surgery, rehabilitation robots and assistive robots • Adaptation and Learning in Human-Robot Interaction • Design criteria and regulations for AI-based medical systems
6	**Learning objectives and skills**	• Students are able to employ artificial intelligence technologies and methods for applications in medical robotics. • They are capable of understanding and handling the complexity of biorobotic AI systems and have command of a versatile set of methods for analyzing and further advancing such systems. • They are able to combine different tools and methods to achieve intelligent perception, planning, control, learning and cognition in robotic solutions for minimally invasive surgery, motor rehabilitation robotics, and medical service robotics.
7	**Prerequisites**	Participants should be familiar with fundamentals of linear algebra. It is advantageous but not required to be have some prior knowledge on robotics, basic methodologies of AI, and basic probability theory.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242

10	**Method of examination**	Written examination Written examination (60 min)
11	**Grading procedure**	Written examination (100%) Written examination (100 %)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 47678	**Algorithmische Bioinformatik** Algorithmic Bioinformatics	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Algorithmic Bioinformatics (4 SWS)	5 ECTS
3	Lecturers	Suryadipto Sarkar Prof. Dr. David Blumenthal	

4	**Module coordinator**	Prof. Dr. David Blumenthal
5	**Contents**	With the growing amount of readily available molecular profiling data, algorithms for analyzing these data are getting more and more important. This lecture provides a close-up view on a selection of these algorithms and introduces the biomedical problems which are addressed by them. In particular, the lecture will cover the following topics: • A very brief introduction to molecular biology. • Algorithms for global and local sequence alignment. • Algorithms for de novo sequence assembly. • Algorithms for secondary RNA structure prediction. • Algorithms for exploratory omics data analysis. • Algorithms for network alignment. • Algorithms for disease mechanism mining in biological networks.
6	**Learning objectives and skills**	Students will • be able to explain the basics of molecular biology, • be able to explain fundamental algorithms used in the field, • be able to use paradigms of algorithm design such as dynamic programming, local search, and ant colony optimization in concrete application scenarios, • be able to reimplement the covered algorithms, • be able to provide detailed, technical explanations of the covered algorithms.
7	**Prerequisites**	Since the lecture will be accompanied by programming exercises in Python, prior knowledge of this programming language is recommended. For students without prior experience, a very brief introduction to Python will be provided in the first two exercise sessions.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english

16	**Bibliography**	Pointers to relevant papers will be provided throughout the lecture and be made available on StudOn. As optional accompanying literature, the following textbooks are recommended: • Phillip Compeau & Pavel Pevzner: Bioinformatics Algorithms: An Active Learning Approach, Active Learning Publishers, 2018. • Patrick Siarry (Ed.): Metaheuristics, Springer International Publishing, 2016.

1	**Module name** 47544	**Applied Data Science in Medicine & Psychology** Applied data science in medicine & psychology	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Luca Abel Prof. Dr. Björn Eskofier Veronika Ringgold Prof. Dr. Nicolas Rohleder
5	**Contents**	The interdisciplinary module „Applied Data Science in Medicine & Psychology“ covers basic statistical knowledge and hands-on Python exercises. We will start with relevant knowledge from both disciplines (statistics and programming), which will allow you to analyze your data more efficiently. Since this is a course for students from many different disciplines (life sciences, psychology, medical engineering, etc.) we will gradually build up your knowledge which will allow you to cover more complex ideas as we move through the course. Our goal is to provide you with the necessary knowledge, skills, and tools for future projects, such as theses, and to prepare those of you who wish to pursue a career in science. This course will also complement the seminars „Digital Health Psychology“ and „Digitalization in Clinical Psychology“, as prior knowledge of Python and data analysis will enhance the benefit of both seminars for you.
6	**Learning objectives and skills**	Students: • Develop a programming mindset • Gain an understanding of research data management • Acquire basic python coding skills • Gain a basic understanding of inference statistic • Can load, manipulate, analyze, and visualize data • Understand basics of machine learning
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable Exam, 60 min
11	**Grading procedure**	Variable (100%) Exam (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h

		Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 47587	**Best Practices in Open Science** Best practices in open science	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Best Practices in Open Science (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Nicolas Rohleder Prof. Dr. Björn Eskofier Veronika Ringgold Luca Abel	

4	**Module coordinator**	Luca Abel Prof. Dr. Björn Eskofier Veronika Ringgold Prof. Dr. Nicolas Rohleder
5	**Contents**	The interdisciplinary lecture and exercise „Best Practices in Open Science“ covers the topics that researchers and (young) scientists should know about the Open Science movement. We will start by explaining the importance of open and reproducible science and how researchers, institutions and the general public benefit from it. We will discuss the Pros and Cons as well as best and worst practices and case studies. After completing this course, students will have gained an overview over the steps to take for more accountability in their own research. Our goal is to provide you with the necessary knowledge, skills, and tools for future projects, such as theses, and to prepare those of you who wish to pursue a career in science.
6	**Learning objectives and skills**	Students: • Gain an understanding of the importance of Open Science • Understand concepts such as open data, open access and reproducibility • Will know about best (and worst) practices • Acquire the relevant knowledge to make their own research more open • Can plan and pre-register a study as well as share (reproducible) code
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable Written Exam, English, (60 min)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h

14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 23070	**Biomedizinische Signalanalyse** Biomedical signal analysis	**5 ECTS**
2	Courses / lectures	Übung: BioSig-UE (2 SWS) Vorlesung: Biomedizinische Signalanalyse (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Naga Venkata Sai Jitin Jami Arijana Bohr Katharina Jäger Sophie Fischerauer Daniel Krauß Prof. Dr. Björn Eskofier	

4	**Module coordinator**	Prof. Dr. Björn Eskofier Daniel Krauß
5	**Contents**	**Inhalt** Im Rahmen der Vorlesung werden (a) die Grundlagen der Generation von wichtigen Biosignalen im menschlichen Körper, (b) die Messung von Biosignalen und (c) Methoden zur Analyse von Biosignalen erläutert und dargestellt. Behandelte Biosignale sind unter anderem Aktionspotential (AP), Elektrokardiogramm (EKG), Elektromyogramm (EMG), Elektroenzephalogramm (EEG), oder Mechanomyogramm (MMG). Bei der Messung liegt der Fokus beispielsweise auf der Messtechnik oder der korrekten Sensor- bzw. Elektrodenanbringung. Im größten Teil der Vorlesung, Analyse von Biosignalen, werden Konzepte zur Filterung für die Artefaktreduktion, der Wavelet Analyse, der Ereigniserkennung und der Wellenformanalyse behandelt. Zum Schluss wird einen Einblick in überwachte Verfahren der Mustererkennung gegeben. Für weitere Informationen, besuchen Sie bitte unseren zugehörigen StudOn Kurs. **Content** The lecture content explains and outlines (a) basics for the generation of important biosignals of the human body, (b) measurement of biosignals, and (c) methods for biosignals analysis. Considered biosignals are among others action potential (AP), electrocardiogram (ECG), electromyogram (EMG), electroencephalogram (EEG), or mechanomyogram (MMG). The focus during the measurement part is for example the measurement technology or the correct sensor and electrode placement. The main part of the lecture is the analysis part. In this part, concepts like filtering for artifact reduction, wavelet analysis, event detection or waveform analysis are covered. In the end, an insight into pattern recognition methods is obtained. For more information, please visit our associated StudOn course
6	**Learning objectives and skills**	**Die Studierenden können nach erfolgreichem Abschluss des Kurses** **Fachkompetenz** **Wissen**

- die Entstehung, Messung und Charakteristika der wichtigsten Biosignale des menschlichen Körpers wiedergeben

Verstehen

- die wesentlichen Ursachen von Artefakten in Biosignalen erklären
- Zusammenhänge zwischen der Entstehung der Biosignale des menschlichen Körper und dem gemessenen Signal erklären
- Messmethoden der wichtigsten Biosignale erklären
- Filteroperationen zur Eliminierung von Artefakten erläutern
- bekannte Algorithmen der Verarbeitung bestimmter Biosignal erklären (z.B. Pan Tompkins für EKG)
- typische Komponenten und ihre Bedeutung in einer generischen Signalanalyse Kette erläutern
- die Struktur und Funktionsweise von Systemen zur maschinellen Klassifikation einfacher Muster darstellen

Anwenden

- Signalcharakteristiken im Zeit- und Frequenzbereich bestimmen
- Algorithmen der Biosignalverarbeitung anwenden und in Python implementieren
- Filteroperationen zur Eliminierung von Artefakten anwenden und in Python implementieren
- Methoden selbstständig auf interdisziplinäre Fragestellungen der Medizin und der Ingenieurwissenschaften anwenden
- das Ergebnis von typischen Filteroperationen abschätzen

Analysieren

- Filtercharakteristika von Schaltkreisen ableiten
- Algorithmen der Biosignalverarbeitung vergleichen
- Klassifikationsprobleme in Python lösen
- Typische Artefakte in Biosignalen erkennen und Lösungsstrategien vorschlagen

Evaluieren (Beurteilen)

- Biosignale mit medizinischen Normalwerten vergleichen und im medizinischen Kontext evaluieren
- Klassifikationsergebnisse beurteilen
- die Bedeutung der Biosignalverarbeitung für die Medizintechnik diskutieren
- Probleme in Gruppen kooperativ und verantwortlich lösen und in der Übungsgruppe bzw. im Forum diskutieren

After completion of the course, students are able to

Knowledge

- reproduce the generation, measurement, and characteristics of important biosignals of the human body

Understanding

- explain the causes of artifacts in biosignals
- explain relations between the generation of biosignals and the measured signal

		• explain methods for the measurement of important biosignals • explain filter operations for the reduction of artifacts • explain algorithms for the analysis of important biosignals (e.g. Pan Tompkins for EKG) • explain typical components and their importance in the signal analysis chain • explain the structure and functioning of systems for machine learning and pattern recognition **Application** • determine signal characteristics in the time and frequency domain • apply and implement algorithms for signal analysis in Python • implement filter operations for the reduction of artifacts in Python • estimate the result of filter operations • apply methods to interdisciplinary problems in medicine and medical engineering **Analyze** • derive filter characteristics from electric circuits • compare signal analysis algorithms • solve classification problems in Python • recognize typical artifacts in biosignals and propose solutions for their reduction **Evaluation** • compare biosignals with medical norm values and evaluate them in a medical context • evaluate classification results • discuss the importance of biomedical signal analysis for medical engineering • solve and discuss problems in groups cooperatively in the group excercises and the online forum

7	**Prerequisites**	**Prerequisites**
		The Biosig lectures and exercises do not have formal requirements. However, we expect you to have some knowledge about the following topics:
		• Basics of Physiology and Anatomy (High-school level)
		•
		  ◦ Basic elements of electronic circuits (resistor, capacitor, inductor) and related equations
		• Basic math: Integration, Differentiation, Limits
		•
		  ◦ Fourier Transform (qualitative understanding)
		  ◦ Basic filter types
		  ◦ z-plane (qualitative understanding)
		
		Furthermore, some knowledge in the following topics will be beneficial to easily understand the content of the lecture:
		
		• Advanced filter concepts

		• z-plane math / z-transform / pole-zero plots • Frequency domain math / detailed understanding of Fourier transform and its properties • Laplace transform • Basics of Python (for the exercises) If you want to refresh your knowledge on all the aforementioned topics, we recommend the following lectures and online resources: Note that some of them go beyond the requirements of this lecture for many topics! • Signals and Systems I • Grundlagen der Anatomie und Physiologie für Medizintechniker • Video Series: Introduction to discrete Control (and further videos from this channel, as general introduction to filter and z-plane math) • A visual introduction to Fourier Transform • Udacity Python Course Course materials from the Stanford "Introduction to Scientific Python"
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242 Electronic Exam (in presence), 90min.
10	**Method of examination**	Electronic examination
11	**Grading procedure**	Electronic examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• R.M. Rangayyan, Biomedical Signal Analysis: A case-study approach. 1st ed., 2002, New York, NY: John Wiley & Sons. • E.N. Bruce, Biomedical Signal Processing and Signal Modeling. 1st ed., 2001, New York, NY: John Wiley & Sons.

1	**Module name** 44445	**Cognitive Neuroscience for AI Developers** Cognitive neuroscience for AI developers	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers. **From WS 24/25 on, this module is only offered in the SS.**	
3	Lecturers	-	

4	**Module coordinator**	
5	**Contents**	Neuroscience has played a key role in the history of artificial intelligence (AI), and has been an inspiration for building human-like AI, i.e. to design AI systems that emulate human intelligence. Neuroscience provides a vast number of methods to decipher the representational and computational principles of biological neural networks, which can in turn be used to understand artificial neural networks and help to solve the so called black box problem. This endeavour is called neuroscience 2.0 or machine behaviour. In addition, transferring design and processing principles from biology to computer science promises novel solutions for contemporary challenges in the field of machine learning. This research direction is called neuroscience-inspired artificial intelligence. The course will cover the most important works which provide the cornerstone knowledge to understand the biological foundations of cognition and AI, and applications in the areas of AI-based modelling of brain function, neuroscience-inspired AI and reverse-engineering of artificial neural networks.
6	**Learning objectives and skills**	The students • Explain the principles of neural information processing in the brain • compare and analyze methods from neuroscience to study neural networks • explain the neuroscientific underpinnings of artificial intelligence • explain principles and concepts of cognitive science • explain principles and concepts of neuroscience • compare and analyze machine learning methods to analyze neural data • explain approaches from deep learning to model brain function • discuss the commonalities of neuroscience and artificial intelligence • implement the presented methods in Python • explain concepts from cognitive neuroscience for the design of artificial intelligence systems
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5

9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination (90 minutes) Written examination, 90 min.
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 90 h Independent study: 60 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Gazzaniga, Michael. Cognitive Neuroscience - The Biology of the Mind. W. W. Norton & Company, 2018. Ward, Jamie. The Student's Guide to Cognitive Neuroscience. Taylor & Francis Ltd., 2019. Bermúdez, José Luis. Cognitive Science: An Introduction to the Science of the Mind. Cambridge University Press, 2014. Friedenberg, Jay D., and Silverman, Gordon W. Cognitive Science: An Introduction to the Study of Mind. SAGE Publications, Inc., 2015. Gerstner, Wulfram, et al. Neuronal dynamics: From single neurons to networks and models of cognition. Cambridge University Press, 2014.

1	**Module name** 93109	**Computational Magnetic Resonance Imaging** Computational magnetic resonance imaging	**5 ECTS**
2	Courses / lectures	Vorlesung: Computational Magnetic Resonance Imaging Vorlesung (2 SWS) Übung: Computational Magnetic Resonance Imaging Uebung (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr. Florian Knoll Jinho Kim	

4	**Module coordinator**	Prof. Dr. Florian Knoll
5	**Contents**	Computational Magnetic Resonance Imaging provides a deeper look into computational and machine learning methods for the inverse problem of MRI data acquisition and image reconstruction. It is organized as a series of lectures with accompanying programming exercises. In the exercises, students will use Matlab or Python and PyTorch to implement and test the different methods discussed in class. Topics covered will include but are not limited to: • Recap of MR signal and encoding, Fourier imaging • Introduction to the inverse problem of imaging • Partial Fourier imaging • Parallel imaging • Compressed sensing • Machine Learning in MRI
6	**Learning objectives and skills**	After completing this course, students will be able to: • Understand the theory and algorithms of MR data acquisition and image reconstruction • Apply them themselves in real-world MR imaging tasks
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Tutorial achievement Variable
11	**Grading procedure**	Tutorial achievement (0%) Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Z.P. Liang. Constrained Reconstruction Methods in MR Imaging.

		http://mri.beckman.illinois.edu/resources/liang_1992_constrained_imaging_review.pdf D. Nishimura. Principles of Magnetic Resonance Imaging. https://www.lulu.com/en/us/shop/dwight-nishimura/principles-of-magnetic-resonance-imaging/paperback/product-1nqdq4j2.html?page=1&pageSize=4 M. Bernstein. Handbook of MRI Pulse Sequences. https://www.amazon.com/Handbook-Pulse-Sequences-Matt-Bernstein/dp/0120928612

1	**Module name** 44200	**Computational Neurotechnology / Numerische Neurotechnologie** Computational neurotechnology / Numerical neurotechnology	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Tobias Reichenbach
5	**Contents**	Foundations of Computational Neuroscience and the processing of neural signals. Applications in the areas of artificial neural networks, Brain-Machine-Interfaces (BCIs) and neural prosthesis.
6	**Learning objectives and skills**	• Can understand the principles of the analysis of neural signals • Can apply information theory for the description of neural activity • Can perform simulations of the dynamics of single neurons as well as of neural networks • Can evaluate different approaches to construct Brain-Machine-Interfaces (BCIs) • Can explain concepts for the design of neural prosthesis
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Written examination Written exam (60 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 56 h Independent study: 94 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Dayan, Peter, and Laurence F. Abbott. Theoretical neuroscience: computational and mathematical modeling of neural systems. Computational Neuroscience Series, 2001. Gerstner, Wulfram, et al. Neuronal dynamics: From single neurons to networks and models of cognition. Cambridge University Press, 2014. Oweiss, Karim G., ed. Statistical signal processing for neuroscience and neurotechnology. Academic Press, 2010.

		Maurits, Natasha. From neurology to methodology and back: an introduction to clinical neuroengineering. Springer Science & Business Media, 2011. Clément, Claude. Brain-Computer Interface Technologies. Springer International Publishing, 2019. DiLorenzo, Daniel J., and Joseph D. Bronzino, eds. Neuroengineering. CRC Press, 2007.

1	**Module name** 645618	**Human Computer Interaction** Human computer interaction	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Björn Eskofier Madeleine Flaucher
5	**Contents**	Das Modul vermittelt Konzepte, Prinzipien, Modelle, Methoden und Techniken für die effektive Entwicklung von benutzerfreundlichen Mensch-Computer-Schnittstellen. Das Thema moderner Benutzungsschnittstellen wird dabei für klassische Computer aber auch für mobile Geräte, eingebettete Systeme, Automobile und intelligente Umgebungen betrachtet. Die folgenden Themen werden im Modul behandelt: • Einführung in die Grundlagen der Mensch-Computer-Interaktion, historische Entwicklung • Entwurfsprinzipien und Modelle für moderne Benutzungsschnittstellen und interaktive Systeme • Informationsverarbeitung des Menschen, Wahrnehmung, Motorik, Eigenschaften und Fähigkeiten des Benutzers • Interaktionskonzepte und -stile, Metaphern, Normen, Regeln und Style Guides • Ein- und Ausgabegeräte, Entwurfsraum für interaktive Systeme • Analyse-, Entwurfs- und Entwicklungsmethoden und -werkzeuge für Benutzungsschnittstellen • Prototypische Realisierung und Implementierung von interaktiven Systemen, Werkzeuge • Architekturen für interaktive Systeme, User Interface Toolkits und Komponenten • Akzeptanz, Evaluationsmethoden und Qualitätssicherung Contents: The module aims to teach basic knowledge of concepts, principles, models, methods and techniques for developing highly user-friendly Human-Computer Interfaces. Beyond traditional computer systems, modern user interfaces are also discussed in the context of automobile and intelligent environments, mobile devices and embedded systems. This module addresses the following topics: • Introduction to the basics of Human-Computer Interaction • Design principles and models for modern user interfaces and interactive systems • Information processing of humans, perception, motor skills, properties and skills of the users • Interaction concepts, metaphors, standards, norms and style guides

		• In- and output devices, design space for interactive systems • Analysis-, design- and development of methodologies and tools for easy-to-use user interfaces • Prototypic implementation of interactive systems • Architectures for interactive systems, User Interface Toolkits and components • Acceptance, evaluation methods and quality assurance
6	**Learning objectives and skills**	• Studierende entwickeln ein Verständnis für Modelle, Methoden und Konzepte der Mensch-Computer-Interaktion. • Sie lernen verschiedene Ansätze für den Entwurf, die Entwicklung und Bewertung von Benutzungsschnittstellen kennen und verstehen deren Vor- und Nachteile. • Die Teilnahme an der Veranstaltung versetzt Studierende in die Lage, einen Entwicklungsprozess in der Mensch-Computer-Interaktion zu verstehen und umzusetzen. • Sie werden weiterhin in die Lage versetzt, dies vor dem Hintergrund der Informationsverarbeitungsfähigkeit, Wahrnehmung und Motorik des Benutzers zu gestalten. • Passende Methoden der Evaluation sowie Akzeptanz- und Qualitätssicherung werden erlernt. Learning Objectives and Competences: • Students develop an understanding of models, methods and concepts in the field of Human-Computer Interaction. • They learn different approaches for designing, developing and evaluating User Interfaces and their advantages and disadvantages. • Joining the course enables students to understand and execute a development process in Human-Computer Interaction. • Students will be able to do a UI evaluation by learning the basics of information processing, perception and motoric skills of the user. • Appropriate evaluation methods, as well as acceptance and quality assurance aspects, will be learned.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Electronic examination Electronic exam (in presence), 90min
11	**Grading procedure**	Electronic examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 47616	**Intent Detection and Feedback** Intent detection and feedback	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Claudio Castellini
5	**Contents**	• Introduction to the problems of intent detection and somatosensory feedback: motivation, taxonomy, historical background. • Intent detection: theory and philosophical issues; defining the problem and the ground truth; success metrics; signals for intent detection; sensors for intent detection; feature extraction; applications of machine learning to the problem. • Somatosensory feedback: theory and physiology; sensory substitution; embodiment and agency induced by it; modalities of actuation; practical issues and metrics of performance. • Intent detection and somatosensory feedback in prosthetics: usefulness, success and challenges. • Intent detection and somatosensory feedback in rehabilitation and exoskeletons: usefulness, success and challenges. • Intent detection and somatosensory feedback in gaming and non-reha fields.
6	**Learning objectives and skills**	Students who have followed the module • have a broad understanding of intent detection and somatosensory feedback, especially in the frame of Rehabilitation and Assistive Robotics • can conceive and design a research project in the related subfield of the subject • have knowledge about the clinical and industrial situation of intent detection and feedback, especially including the problems and challenges of each technique and method • can tackle previously unknown problems
7	**Prerequisites**	Recommended: basic maths, especially statistics; fundamentals of signal processing and machine learning; mid-level programming Python, C# or similar; fundamentals of experimental psychology
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable (60 minutes) Written examination (60 min)
11	**Grading procedure**	Variable (100%) Written examination (100 %)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h

		Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• [2010] Control of Hand Prostheses Using Peripheral Information, S. Micera, J. Carpaneto and S. Raspopović. • [2012] Control of Upper Limb Prostheses: Terminology and Proportional Myoelectric ControlA Review, A. Fougner, Ø. Stavdahl, P. J. Kyberd, Y. G. Losier and P. A. Parker. • [2015] Michael R Tucker et al., Control strategies for active lower extremity prosthetics and orthotics: a review, JNER 12:1 • [2015] A survey of sensor fusion methods in wearable robotics, D. Novak and R. Riener • [2016] Incremental Learning of Muscle Synergies: From Calibration to Interaction, C. Castellini. • [2018] JA Spanias, AM Simon, SB Finucane, EJ Perreault and LJ Hargrove, Online adaptive neural control of a robotic lower limb prosthesis, J Neural Eng. 15(1) • [2020] Jacob Rosen and Peter Walker Ferguson (eds.), Wearable Robotics Systems and Applications, Academic Press Elsevier • [2021] Michele Xiloyannis, Ryan Alicea, Anna-Maria Georgarakis, Florian L. Haufe, Peter Wolf, Lorenzo Masia and Robert Riener, Soft robotic suits: State of the art, core technologies and open challenges, IEEE Transactions on Robotics

1	**Module name** 93340	**Introduction to Network Science** Introduction to network science	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. David Blumenthal
5	**Contents**	Networks are fundamental data structures for modeling and analyzing complex biological, technological, or social systems. This course provides an introduction to the science of complex networks and their applications. The following topics will be covered: • Very brief introduction to graph theory, the mathematical underpinning of network science, • node centrality measures, • models of random networks, • network motifs, • degree correlations, • community detection, • network distance models, • evolving networks, • temporal networks.
6	**Learning objectives and skills**	Students will • get familiar with the basics of graph theory, • learn how to use networks to model complex relationships, • get familiar with the most important techniques for analyzing complex networks, • acquire hands-on experience in analyzing complex networks with the widely used Python library NetworkX.
7	**Prerequisites**	Since the lecture will be accompanied by programming exercises in Python, prior knowledge of this programming language is recommended. For students without prior experience, a very brief introduction to Python will be provided in the first two exercise sessions.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english

16	**Bibliography**	A. Barabási and M. Pósfai, Network Science, Cambridge University Press, Cambridge, 2016, http://barabasi.com/networksciencebook/.

1	**Module name** 428256	**Maschinelles Lernen für Zeitreihen** Machine learning for time series	**5 ECTS**
2	Courses / lectures	Vorlesung: Lecture Machine Learning for Time Series (2 SWS) Übung: Machine Learning for Time Series Exercise (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr. Björn Eskofier Dr. Dario Zanca Dr. Emmanuelle Salin Richard Dirauf	

4	**Module coordinator**	Prof. Dr. Björn Eskofier Dr. Dario Zanca
5	**Contents**	Aim of the lecture is to teach Machine learning (ML) and Deep Learning (DL) methods for a variety of time series applications. The following topics will be covered: • Fundamentals and an overview of applications of time series analysis. • Fundamentals of ML methods, such as Gaussian processes, State Space models, and Autoregressive models for time series. • Design, implementation and evaluation of ML methods in order to address time series problems. • Advanced DL methods for time-series, such as Convolutional, Recurrent, and Attention-based models. • Working with widely-used toolboxes that can be used for implementation of ML methods, such as Tensorflow or PyTorch.
6	**Learning objectives and skills**	• Students can describe concepts of time series problems and their wide applications in industry, medicine, finance, etc. • Students can explain concepts of ML/DL methods in general and tackling time series problems in particular • Students understand the characteristics of time series data and are capable of developing and implementing ML/DL methods to model, predict and manipulate such data in concrete problems
7	**Prerequisites**	This is a specialisation lecture; successful completion of the lectures "IntroPR" and/or "Pattern Recognition" / "Pattern Analysis" is recommended. Concepts taught in "IntroPR" are assumed here as basic knowledge.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	electronic exam (remote), 90 min. Written examination (90 minutes)

11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Pattern recognition and machine learning. Christopher M. Bishop, Springer, 2006 • The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Trevor Hastie, Robert Tibshirani, Jerome Friedman, Springer, 2009 • Machine Learning: A Probabilistic Perspective. Kevin Murphy, MIT press, 2012 • Deep Learning. Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016

1	**Module name** 47582	**Systems Immunology and Infectiology** Systems immunology and infectiology	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Systems Immunology and Infectiology (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Frederik Graw	

4	**Module coordinator**	Prof. Dr. Frederik Graw
5	**Contents**	The lecture will cover selected topics in systems immunology and infectiology, which aim at revealing the complex dynamical processes during infection, inflammation and cancer. We will learn different concepts of using mathematical models and computational methods to address fundamental questions of immune and infection dynamics. This includes among others the spread of pathogens within hosts, the dynamics of immune responses and the evolution of drug resistance. In the various lectures, we will investigate how different data analytical methods and concepts (e.g., from mathematical modelling, bioinformatics and ML) play a pivotal role in understanding infection and immunity. The lectures are accompanied by tutorials with practical exercises, including small programming exercises in R.
6	**Learning objectives and skills**	The participants will learn • to analyse immunological and virological data • to apply basic methods for analysing dynamic processes • to use basic concepts of mathematical modelling to study complex systems and dynamics
7	**Prerequisites**	The following prerequisites are strongly recommended • Basic knowledge of mathematics and dynamical systems (ordinary differential equations, statistics) • Basic knowledge of the programming language R • Interest in data analytical methods
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Electives Bachelor of Science Artificial Intelligence 20242 This course is appropriate for students within their last year of BSc in quantitative disciplines or MSc students interested in immunological data sciences (e.g. BSc/MSc Artificial Intelligence; BSc/MSc Data Science; MSc Medical Engineering; MSc Molecular Medicine; MSc Integrated Life Sciences; MSc Integrated Immunology).
10	**Method of examination**	Variable Oral examination at end of semester
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h

		Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Keeling MJ & Rohani P: Modeling Infectious Diseases in Humans and Animals, Princeton Univ. Press 2009 • Nowak MA & May RM: Virus dynamics, Oxford Univ. Press 2000 • Murray JD: Mathematical Biology II – Spatial models and Biomedical applications, Springer 2004

Artificial Intelligence Seminar

Students choose 1 module from the "AI Seminar" catalog.

1	**Module name** 47704	**Digitalization in Clinical Psychology**	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Luca Abel Prof. Dr. Björn Eskofier
5	**Contents**	The interdisciplinary course „Digitalization in Clinical Psychology“ is designed for students of psychology, medical engineering and neighboring sciences. Current issues from the fields of digital health and psychotherapy research are addressed in groups. The goal of this research-oriented course is to strengthen the cooperation between the individual disciplines in order to make optimal use of mutual synergy effects. Students will use their individual skills learned during their studies in interdisciplinary teams to benefit from each other. In addition to the planning and execution of a research question as well as analysis of the results in groups, there will also be teaching units of the different disciplines during the semester, such as basic knowledge about psychological, psychosomatic and neuropsychological diseases and their psychotherapeutic treatment, hypothesis-driven planning and execution of experiments, inferential statistics, data analysis in Python, and acquisition and processing of physiological signals. In addition, fundamentals of scientific work and research data management are taught.
6	**Learning objectives and skills**	Students: • can explain current developments at the intersection of digital health and psychology • are able to independently research, evaluate and present a topic in the context of clinical psychology • can identify opportunities and challenges of machine learning and digital health in the field of psychology • are able to identify and understand relevant literature and present findings in a structured manner • can present implementation and validation results in the form of a presentation and a scientific paper.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement

		Seminar achievement (presentation, c.a. 30 min., and written report)
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 45 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 47614	**Green AI - AI for sustainability and sustainability of AI**	**5 ECTS**
2	Courses / lectures	Hauptseminar: Green AI - AI for Sustainability and Sustainability of AI (2 SWS)	5 ECTS
3	Lecturers	René Raab Prof. Dr. Björn Eskofier Eva Dorschky	

4	**Module coordinator**	Eva Dorschky Prof. Dr. Björn Eskofier
5	**Contents**	Can we use AI to combat global climate change? How can advances in machine learning and data science help to monitor climate crises and to conserve nature? What is the role of AI in reducing greenhouse gas emissions in the manufacturing industries, transportation infrastructure, agriculture, and power sector? In this module, we will develop and discuss future perspectives of AI for sustainability, considering the sustainability of AI itself. Current advances in machine learning, particularly deep learning, are enabling new applications but are accompanied by an exponential increase in computational cost and thus significant carbon emissions (Schwartz et al., 2020; Vinuesa et al., 2020). In this seminar, we will learn about important aspects of improving the sustainability of machine learning algorithms. This seminar offers a different perspective on machine learning as taught in other courses, namely its role in global climate change. This aspect is becoming increasingly important in research, but also in industry. Therefore, this seminar provides the following items: • Introduction to "Green AI" versus "Red AI" • Guests talks on related research topics • Group discussions on future prospects of AI, specifically machine learning • Best practices for literature review and scientific presentations • Literature review on Green AI in certain areas in groups • Scientific talk of each student on one specific topic
6	**Learning objectives and skills**	Students will analyze • the opportunities that AI offers to combat global climate change • the negative impact of AI on global climate change • current research topics in the field of "Green AI" Students will be able to • discuss and work in a group • perform and write a literature review • give a scientific presentation
7	**Prerequisites**	Basic knowledge in machine learning is required to take part in the seminar. Students are expected to have completed one or more basic courses, such as PR, PA, IntroPR, DL, MTLS, or equivalent.
8	**Integration in curriculum**	semester: 5

9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement Die Prüfung besteht aus einer schriftlichen Gruppenarbeit (4 Seiten) und einer individuellen Präsentation (15 Minuten + 5 Minuten Diskussion). The examination consists of a written group paper (4 pages) and an individual presentation (15 minutes + 5 minutes discussion).
11	**Grading procedure**	Seminar achievement (100%) Die Note ergibt sich aus der Bewertung der schriftlichen Arbeit (40%) und der Präsentation (60%). The grade results from the evaluation of the written paper (40%) and the presentation (60%).
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Schwartz, Roy et al. (2020). "Green ai. In: Communications of the ACM 63.12, pp. 54 63. Vinuesa, Ricardo et al. (2020). "The role of artificial intelligence in achieving the Sustainable Development Goals. In: Nature communications 11.1, pp. 110.

1	**Module name** 47619	**Seminar Machine Learning in MRI** Seminar: Machine learning in MRI	**5 ECTS**
2	Courses / lectures	Hauptseminar: Machine Learning in MRI (4 SWS, WiSe 2024) Attendance is compulsory for the mid-term presentations.	5 ECTS
3	Lecturers	Erik Gösche Vanya Saksena Prof. Dr. Florian Knoll	

4	**Module coordinator**	Prof. Dr. Florian Knoll
5	**Contents**	We will cover recent machine learning developments in the areas of Magnetic Resonance (MR) data acquisition, image generation, image analysis and image interpretation. We will go over papers from leading international journals and conferences. Students can either suggest their own topics/papers or select from a range of papers presented by the lecturers. Each student will then study the assigned papers, discuss them with the lectures and at the end of the semester give a presentation about the key findings.
6	**Learning objectives and skills**	After completing this course, students will be able to: • critically read and understand a scientific paper in the fields of medical imaging and machine learning. • present a complex topic in their own words to their peers.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement Presentation (20 Minutes + 10 Minutes discussion) Written report (5-7 pages)
11	**Grading procedure**	Seminar achievement (100%) Presentation and discussion 50%, Report 50%
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 45 h
14	**Module duration**	1 Semester semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 903776	**Seminar Machine Learning and Data Analytics for Industry 4.0** Seminar machine learning and data analytics for industry 4.0	**5 ECTS**
2	Courses / lectures	No courses / lectures available for this module! Es besteht Anwesenheitspflicht.	
3	Lecturers	No lecturers available since there are no courses / lectures for this module!	

4	**Module coordinator**	Prof. Dr. Björn Eskofier An Nguyen Johannes Roider
5	**Contents**	Companies in all kinds of industries are producing and collecting rapidly more and more data from various sources. This is enabled by technologies such as the Internet of Things (IoT), Cyber-physical systems (CPS) and cloud computing. Hence, there is an increasing demand in industry and research for students and graduates with machine learning and data analytics skills in the Industry 4.0 context. The goal of this seminar is to give students insights about state-of-the-art machine learning and data analytics methods for industrial and business applications. In this seminar, the Industry 4.0 term will not only be limited to manufacturing processes, but comprise all business functions. Students will mainly work independently on either an implementation-centric or a research-centric topic. The implementation-centric topics will focus primarily on the implementation of algorithms and analytical components (using provided or open source datasets), while the research-centric topics will focus on researching and structuring literature of a specific field of interest. Several topics will be provided, but students are also encouraged to propose their own topics when applying for the seminar. In the regular meetings, students will learn about fundamentals and trends in Industry 4.0 from a machine learning perspective, common machine learning techniques and their implementation, project management of data analytics projects in businesses, as well as best practices for presentations and scientific work. The programme will be complemented by talks from invited experts in the domain. Furthermore, students will present results from literature research and data analytics projects.
6	**Learning objectives and skills**	• Students will develop an understanding of the current hot field of machine learning and data analytics in businesses • Students will learn to research and present a topic within the context of machine learning and data analytics in businesses independently • Students will learn to identify opportunities, challenges and limitations of corresponding ML approaches in businesses

		• Students will develop the skill to identify and understand relevant literature and to present their findings in a structured manner • Students will learn to present implementation and validation results in form of a demonstration and/or report
7	**Prerequisites**	• Prior knowledge of machine learning via courses like Pattern Analysis, Pattern Recognition, Deep Learning, Machine Learning for Time Series, or equivalent is expected. Alternatively, first data science project experience, for example as working student in a company, can be sufficient. • Motivation to explore scientific findings (e.g. via literature research) • Motivation to code and analyze data
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement
11	**Grading procedure**	Seminar achievement (100%) • 50% of grade: Presentation (20 minutes) • 50% of grade: 4 pages IEEE standard paper (excluding references) (+ code submission)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Lei, Yaguo, Naipeng Li, Liang Guo, Ningbo Li, Tao Yan, and Jing Lin. "Machinery Health Prognostics: A Systematic Review from Data Acquisition to RUL Prediction. Mechanical Systems and Signal Processing 104 (May 2018): 799834.https://doi.org/10.1016/j.ymssp.2017.11.016. • Rojas, Eric, Jorge Munoz-Gama, Marcos Sepúlveda, and Daniel Capurro. "Process Mining in Healthcare: A Literature Review. Journal of Biomedical Informatics 61 (June 1, 2016): 22436. https://doi.org/10.1016/j.jbi.2016.04.007. • Wil M. P. van der Aalst. Process Mining: Data Science in Action 2nd edition, Springer 2016. ISBN 978-3-662-49851-4 • Wang, Lihui, and Xi Vincent Wang. Cloud-Based Cyber-Physical Systems in Manufacturing. Cham: Springer International Publishing, 2018. https://doi.org/10.1007/978-3-319-67693-7.

1	**Module name** 47673	**Network medicine**	**5 ECTS**
2	Courses / lectures	Hauptseminar: Network Medicine (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. David Blumenthal	

4	**Module coordinator**	Prof. Dr. David Blumenthal
5	**Contents**	Network medicine is an emerging research field which leverages techniques from molecular biology, bioinformatics, combinatorial optimization, and artificial intelligence to uncover potential disease mechanisms and candidates for causally effective treatments in heterogeneous molecular networks. In this seminar, students will dive into selected hot topics in network medicine.
6	**Learning objectives and skills**	Students will • be able to explain hot topics in the field of network medicine, • be able to identify, understand, and contextualize relevant research literature, • be able to give a presentation for a scientific audience, • be able to write an academic report.
7	**Prerequisites**	Some prior knowledge in graph theory and/or network science is recommended.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	All relevant literature will be made available in StudOn. For background reading, students can consult the following textbook: • Loscalzo, Joseph, Albert-László Barabási, and Edwin K. Silverman (eds.): Network Medicine: Complex Systems in Human Disease and Therapeutics. Harvard University Press, 2017.

1	**Module name** 47581	**Seminar Quantifying lymphocyte dynamics** Seminar: Quantifying lymphocyte dynamics	**5 ECTS**
2	Courses / lectures	Seminar: Quantifying lymphocyte dynamics (2 SWS)	-
3	Lecturers	Prof. Dr. Frederik Graw	

4	**Module coordinator**	Prof. Dr. Frederik Graw
5	**Contents**	Quantifying and understanding the dynamics of immune cells, i.e., lymphocytes, during health and disease is an important prerequisite for the design of appropriate treatment regimens and vaccination approaches. In this seminar, we will discuss the combination of different types of experimental data with various mathematical, computational and data analytical methods to quantify the generation, proliferation and differentiation dynamics of immune cells. We will see how the advancement of experimental methods, such as cellular barcoding or scRNA-seq, requires more sophisticated data analytical methods, including concepts from machine learning, and how this has advanced our understanding of lymphocyte dynamics.
6	**Learning objectives and skills**	The participants will present various concepts based on scientific papers, discussing the experimental approaches in combination with the mathematical methods. Participants will • learn to combine experimental data and data analytical methods to infer immunological processes • learn to carefully interpret various data types • learn the promises and limitations of different immunological data
7	**Prerequisites**	This interdisciplinary seminar is intended for students with a background in the life sciences and interest for data analytical methods and/or for students from quantitative subjects (AI, Data Science, Mathematics, (Bio-)Physics). Basic knowledge of mathematics (ordinary differential equations, statistics) and interest in interdisciplinary work is strongly recommended.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242 This course is appropriate for students within their last year of BSc in quantitative disciplines or MSc students interested in immunological data science (e.g. BSc/MSc Artificial Intelligence; BSc/MSc Data Science; MSc Medical Engineering; MSc Molecular Medicine; MSc Integrated Life Sciences; MSc Integrated Immunology).
10	**Method of examination**	Seminar achievement Successful participation of the course will be based on • Individual presentation • Written assignment (10-15 pages)

		• Participation in the seminars and discussions
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Exemplary articles: • De Boer et al.: Quantifying T lymphocyte turnover, J. Theo Biol. 2013 • Gossel et al.: Memory CD4 T cell subsets are kinetically heterogeneous and replenished from naive T cells at high levels, Elife 2017 • Gerlach et al.: Heterogeneous Differentiation Patterns of Individual CD8+ T Cells, Science 2013 • Pei et al.: Using Cre-recombinase-driven Polylox barcoding for in vivo fate mapping in mice. Nat. Protocols 2019 • Saelens et al.: A comparison of single-cell trajectory inference methods, Nat Biotechn. 2019

1	**Module name** 93113	**Seminar Humans in the Loop: The Design of Interactive AI Systems** Seminar: Humans in the loop: The design of interactive AI systems	**5 ECTS**
2	Courses / lectures	Hauptseminar: Seminar Humans in the Loop: The Design of Interactive AI Systems (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Bernhard Kainz Johanna Müller	

4	**Module coordinator**	Prof. Dr. Bernhard Kainz
5	**Contents**	This is a joint seminar between Prof. Kainz (FAU Erlangen-Nuremberg) and Prof. Ledig (University of Bamberg). The seminar will take place at Bamberg Campus and FAU Campus. Initial topic selection and pitch presentation will take place in Bamberg. Final topic presentations will take place in Erlangen. Human-in-the-Loop Machine Learning describes processes in which humans and Machine Learning algorithms interact to solve one or more of the following: Making Machine Learning more accurate Getting Machine Learning to the desired accuracy faster Making humans more accurate Making humans more efficient Aim of this seminar is to give students insights about state-of-the-art Active Learning and interactive data analysis methods. Students will work independently on specific topics including implementation and analytical components alongside lectures delivered by the course lead, guest lectures and flipped classroom sessions, where students explore a topic independently, which is then discussed in class. Several potential topics will be provided but students are also encouraged to propose their own topics (after discussion with course lead). Topics covered will include but are not limited to: Introduction to Human-in-the-Loop Machine Learning • Active Learning Strategies: • Uncertainty Sampling • Diversity Sampling • Other Strategies Annotating Data for Machine Learning • Who are the right people to annotate your data? • Quality control for data annotation • User interfaces for data annotation Transfer Learning and Pre-Trained Models • What are Embeddings? • What is Transfer Learning? Adaptive Learning • Machine-Learning for aiding human annotation • Advanced Human-in-the-Loop Machine Learning

		Format The presentations for this seminar will be conducted as block seminar. Dates TBD. We will meet in the beginning of the semester to discuss possible work areas and assign concrete topics to each participant. You will be provided pointers to literature and then independently familiarize yourself with the assigned topic. Towards the end of the semester you will: • present an initial 3-minute pitch about your topic early during the term after topic selection • present your topic as a 20-minute presentation at the end of the term • submit a written report of approximately 8-10 pages. • The seminar will be held in English including presentations and the written report. The presentations will be conducted as a block seminar towards the end of the semester. The weekly hours mentioned in the module description are an optional time slot to get support, guidance and feedback on your topic (as required).
6	**Learning objectives and skills**	You will learn about the potential as well as current challenges when building and translating AI systems into real world applications. The focus of the seminar will be biased towards approaches based on computer vision algorithms and medical image processing. Specifically, you will learn about the state of the art in the context of selected applications. You will also get the opportunity to learn about negative examples of AI systems that failed to deliver on promises, regulatory constraints, patient privacy and data management. The seminar will allow you, based on your interest, to focus on a wide spectrum of aspects ranging from recently published technical solutions to the state of affairs on the policy level. Learning objectives are: • In-depth knowledge of human-in-the-loop machine learning, including deeper insight into current research. • A capability to work independently on application-driven projects. • To use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues. • To follow a scientific approach, formulating hypotheses, validation through experimentation and statistical analysis. • To plan and use adequate methods to conduct qualified tasks in given frameworks and to evaluate this work. • To create, analyse and critically evaluate different technical/ architectural solutions. • To integrate knowledge critically and systematically. • To clearly present and discuss the conclusions as well as the knowledge and arguments that

		• form the basis for these findings in written and spoken Enaglish. • A consciousness of the ethical aspects of research and development work.
7	**Prerequisites**	Prerequisites recommended: Deep Learning ML Prof. Dr. Andreas Maier 2+2 5 x E Pattern Recognition ML Prof. Dr. Andreas Maier 3+1+2 5 x E Maschinelles Lernen für Zeitreihen ML Prof. Eskofier, Prof. Oliver Amft, Dr. Ch. Mutschler 2+2+2 7.5 x E
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 15 h Independent study: 135 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	A specific reading list will be established at the beginning of each term, general literature is listed below: Quinn J, McEachen J, Fullan M, Gardner M, Drummy M. Dive into deep learning: Tools for engagement. Corwin Press; 2019 Jul 15. https://d2l.ai/ Goodfellow I, Bengio Y, Courville A, Bengio Y. Deep learning. Cambridge: MIT press; 2016 Nov 18. https://www.deeplearningbook.org/ Budd S, Robinson EC, Kainz B. A survey on active learning and human-in-the-loop deep learning for medical image analysis. arXiv preprint arXiv:1910.02923. 2019 Oct 7. https://arxiv.org/abs/1910.02923

1	**Module name** 47366	**Seminar Digital Health Psychology** Seminar: Digital health psychology	**5 ECTS**
2	Courses / lectures	Seminar: Digital Health Psychology (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Björn Eskofier Luca Abel Robert Richer Prof. Dr. Nicolas Rohleder Veronika Ringgold	

4	**Module coordinator**	Luca Abel Prof. Dr. Björn Eskofier Veronika Ringgold
5	**Contents**	**This course is the former "Digital Psychology Lab", students who already passed this course cannot participate.** The interdisciplinary course "Digital Health Psychology" is designed for students of psychology and medical engineering. Current issues from the fields of digital health and stress research are addressed in groups. The goal of this research-oriented course is to strengthen the cooperation between the individual disciplines in order to make optimal use of mutual synergy effects. Students will use their individual skills learned during their studies in interdisciplinary teams to benefit from each other. In addition to the planning and execution of a research question as well as analysis of the results in groups, there will also be teaching units of the different disciplines during the semester (psychology: theoretical models and biological basis of stress, hypothesis-driven planning and execution of experiments, collection of biomarkers and their evaluation in the laboratory, inferential statistics; medical engineering: data analysis in Python, acquisition and processing of physiological signals, basics of machine learning). In addition, fundamentals of scientific work and research data management are taught. Topics covered include: - Overview of current issues in the field of machine learning and data analysis for stress research. - Best practices for presenting and writing up scientific results - Best practices for hypothesis-driven design and implementation of experimental and field studies
6	**Learning objectives and skills**	- Students will gain an understanding of the current

		developments at the intersection of digital health and Psychology. - Students will learn to independently research and present a topic in the context of digital health psychology independently and to present it. - Students will learn to identify opportunities, challenges, and limitations of machine learning and digital health in psychology. - Students will develop the ability to identify and understand relevant literature and present their findings in a structured manner. - Students will learn to present implementation and validation results in the form of a presentation and a scientific paper.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Seminar Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Seminar achievement Seminar
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Artificial Intelligence Project

Students choose 1 module from the "AI Project" catalog.

1	**Module name** 43932	**Computational Imaging Project** Computational imaging project	**10 ECTS**
2	Courses / lectures	Projekt: Computational Imaging Project (8 SWS)	10 ECTS
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Florian Knoll
5	**Contents**	Individual or group projects in the area of computational methods in biomedical imaging. The projects range from theoretical analysis to practical implementations of approaches that have recently been published in the literature. Students can either propose their own topics or contact the lecturer for a list of available topics. The project can be done either as 10 ECTS or a 5 ECTS depending on the scope of the work and the study program. If you want to do a project in this semester, please write an email to Prof. Knoll at the beginning of the semester to discuss possible topics.
6	**Learning objectives and skills**	Students acquire and practice the skills to: • Read and discuss literature from the field of biomedical imaging • Implement approaches that are proposed in the literature • Run computational experiments and interpret and communicate their findings in lab meetings
7	**Prerequisites**	Recommended: Computational Magnetic Resonance Imaging Lecture and Medical Engineering II
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Practical achievement The grade is determined by: 50% Software development of approaches from the literature. 25% Presentation of the software and the results in the lab group meeting. 25% Written documentation of the development in form of a project report (max 10 pages).
11	**Grading procedure**	Practical achievement (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 240 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	german english
16	**Bibliography**	An individual reading list will be established at the beginning of each project.

1	**Module name** 615628	**Innovationslabor für Wearable und Ubiquitous Computing** Innovation lab for wearable and ubiquitous computing	**10 ECTS**
2	Courses / lectures	Praktikum/Projekt: Innovationslabor für Wearable und Ubiquitous Computing (4 SWS)	10 ECTS
3	Lecturers	Ann-Kristin Seifer Marlies Nitschke Imrana Abdullahi Yari Charlotte Pradel Alzhraa Ibrahim Matthias Zürl Misha Sadeghi Mohamad Wehbi Nils Roth Alexander Weiß Prof. Dr. Björn Eskofier Johannes Link Michael Nissen	

4	**Module coordinator**	Prof. Dr. Björn Eskofier Matthias Zürl
5	**Contents**	Mini-Computer, die unseren Lebensrhythmus dokumentieren, EKG-Sensoren, die jedes Detail aufzeichnen, Brillen, die uns in eine andere Realität versetzen diesen Technologien begegnen wir mittlerweile ständig im Alltag. Im Innovationslabor für Wearable und Ubiquitous Computing werden solche Technologien von Studierenden entwickelt und gleichzeitig aufgezeigt, wie man mit diesen ein eigenes Startup gründen könnte. Die innovativen Technologien werden dabei prototypisch in Gruppenarbeit (5-8 Studierende) unter Nutzung von agilen Entwicklungsmethoden (Scrum) geschaffen. Den Studierenden steht dabei der Zugang zum Innovationslabor offen, welches mit der nötigen Infrastruktur für die Entwicklung der Prototypen ausgestattet ist. Die Ideen für die Projekte stammen dabei entweder von kooperierenden Firmen oder von den Studierenden selbst. Neben dem Prototyping erlernen die Teilnehmer in Tutorials die Grundlagen für innovatives Arbeiten wie Design Thinking und Patentrecherche. Zudem wird ihnen beigebracht, wie sie nach der Entwicklung ihre Ideen schützen und gegebenenfalls an den Markt bringen können. *Content:* Mini-computers documenting our rhythm of life, EKG-Sensors tracing every detail or glasses, that transfer us into another reality are amongst the technologies we are meanwhile facing in our everyday lives. At the Innovation Lab for Wearable and Ubiquitous Computing students develop such technologies and learn about the possibilities and requirements to build a start-up. By applying agile development methods (Scrum), teams of 5 to 8 students develop prototypes of products within the wearable and ubiquitous computing field. Participating students have

		open access to the Innovation Lab, which provides them with everything they need to develop their prototypes. The project ideas originate from cooperating companies or the students themselves. Besides the great practical experience gained during development, students also learn about entrepreneurship. There will be tutorials covering design thinking, market analysis, management of development processes, securing intellectual property, and business plan creation.
6	**Learning objectives and skills**	• Die Studierenden nutzen in der gemeinsamen agilen Projektentwicklung das Framework SCRUM. • Die Studierenden führen eine Ideation Session mit ihrem Projektpartner durch. • Die Studierenden lernen, die Ergebnisse ihrer Entwicklung sowohl wissenschaftlich als auch im Kontext eines Sales-Pitches zu präsentieren. • Die Studierenden nutzen Gitlab für die gemeinsame Entwicklung von Software-Anwendungen. • Die Studierenden lernen die verschiedensten Aspekte einer Unternehmensgründung kennen. *Learning Goals and skills:* • Students use the agile project management framework SCRUM. • Students conduct an ideation session together with project partners. • Students learn to present their results both in a reseach environment as well as in a sales-pitch environment • Students use Gitlab for the joint development of software applications. • Students are familiarized with various aspects of entrepreneurship and founding.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Portfolio The overall grade consists of four parts: • Team presentation - 30 min, 5 min per student (30%) • Final business pitch and live prototype demonstration - 10 min (10%) • Hardware/software development, Scrum Meetings, Practical work (40%) • Final documentation - approx. 3-6 pages per student (20%)
11	**Grading procedure**	Portfolio (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 47629	**Neurotechnology Project** Project: Neurotechnology	**10 ECTS**
2	Courses / lectures	Praktikum: Neurotechnology Project (8 SWS)	-
3	Lecturers	Prof. Dr. Tobias Reichenbach	

4	**Module coordinator**	Prof. Dr. Tobias Reichenbach
5	**Contents**	Projekte im Bereich der künstlichen neuronalen Netzwerke, der Brain-Machine Interfaces (BCIs) und der neuronalen Prothesen. --- Projects in the field of artificial neural networks, brain-machine interfaces (BCIs) and neural prostheses.
6	**Learning objectives and skills**	Die Studierenden... - Können Prinzipien der Analyse neuronaler Signale benutzen - Können Informationstheorie zur Beschreibung neuronaler Aktivität anwenden - Können die Dynamik einzelner Neurone wie auch von neuronalen Netzwerken mathematisch beschreiben - Können Ansätze zur Konstruktion von Brain-Machine Interfaces (BCIs) implementieren - Können Konzepte zum Design neuronaler Prothesen anwenden --- The students... - can use principles of analysis of neural signals. - can apply information theory to describe neuronal activity. - can describe the dynamics of individual neurons as well as of neural networks mathematically. - can implement approaches to the construction of Brain-Machine Interfaces (BCIs). - can apply concepts to the design of neural prostheses.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242

		This module can be used as a combination of M6.1 (Academic Lab) and M6.2 (Research Lab) in the Master's program Medical Engineering.
10	**Method of examination**	Practical achievement Schriftlicher Bericht (50%) mündlicher Bericht (50%)
11	**Grading procedure**	Practical achievement (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 25 h Independent study: 275 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	
16	**Bibliography**	Dayan, Peter, and Laurence F. Abbott. *Theoretical neuroscience: computational and mathematical modeling of neural systems*. Computational Neuroscience Series, 2001. Gerstner, Wulfram, et al. *Neuronal dynamics: From single neurons to networks and models of cognition*. Cambridge University Press, 2014. Oweiss, Karim G., ed. *Statistical signal processing for neuroscience and neurotechnology*. Academic Press, 2010. Maurits, Natasha. *From neurology to methodology and back: an introduction to clinical neuroengineering*. Springer Science & Business Media, 2011. Clément, Claude. *Brain-Computer Interface Technologies*. Springer International Publishing, 2019. DiLorenzo, Daniel J., and Joseph D. Bronzino, eds. *Neuroengineering*. CRC Press, 2007.

1	**Module name** 47676	**Projekt Biomedical Network Science** Project: Biomedical network science	**10 ECTS**
2	Courses / lectures	Projekt: Projekt Biomedical Network Science (4 SWS)	10 ECTS
3	Lecturers	Prof. Dr. David Blumenthal	

4	**Module coordinator**	Prof. Dr. David Blumenthal
5	**Contents**	The Biomedical Network Science (BIONETS) lab investigates molecular disease mechanisms using techniques from combinatorial optimization, network science, and artificial intelligence. We also develop privacy-preserving decentralized biomedical AI solutions, which enable cross-institutional studies on sensitive data. Students will work on individual research topics within these field and develop prototypes of software tools to solve the addressed problems.
6	**Learning objectives and skills**	Students will be able to • develop and implement an algorithm for a problem within the field of biomedical networks science which, in certain respects, improves upon the state-of-the-art, • apply best practices in software development and documentation, • write an academic report.
7	**Prerequisites**	Strong programming skills in any programming language.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 240 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	All relevant research literature will be made available in StudOn.

1	**Module name** 924553	**Projekt Maschinelles Lernen und Datenanalytik** Project machine learning and data analytics	**10 ECTS**
2	Courses / lectures	Sonstige Lehrveranstaltung: Projekt Maschinelles Lernen und Datenanalytik (2 SWS)	10 ECTS
3	Lecturers	An Nguyen Dr. Dario Zanca Prof. Dr. Björn Eskofier	

4	**Module coordinator**	Prof. Dr. Björn Eskofier An Nguyen Dr. Dario Zanca
5	**Contents**	At the Machine Learning and Data Analytics Lab we offer project topics that are related to our current research in the fields of Machine Learning, Human Computer Interaction, Modeling and Simulation and Wearable Computing. Other than a course with fixed topic, project topics are defined individually. The 10 ECTS project addresses students of computer science and medical engineering. However, most projects can also be offered as 5 ECTS medical engineering internship/praktikum. There will be a kick-off meeting the first Thursday 16:15-18:00 of each semester where topics in the field of machine learning and data analytics will be presented. Most topics will be related to the diverse research fields of the Machine Learning and Data Analytics Lab. Students also have the possibility to discuss their own project ideas with the supervisors. The distribution of topics will be based on prerequisites and first come, first serve in terms of time of registration until all topics are distributed. Students will have to contact the corresponding supervisor for the topic of interest. Additional topics are also presented on our website.
6	**Learning objectives and skills**	The students • work on a machine learning algorithm and implement it • work on complex software systems and expand them • learn to independently develop and implement proposed solutions • document the software they have written
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242 No prerequisites for this course.
10	**Method of examination**	Portfolio The evaluation for projects includes a code repository with the implementation of the work (including proper code documentation), a 15-minute presentation, and a term paper of approximately 10 pages.
11	**Grading procedure**	Portfolio (100%) The overall grade consists of these parts: • 50% graded implementation

		• 25% graded presentation • 25% graded documentation/report
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 240 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	german english
16	**Bibliography**	

1	**Module name** 93112	**Project Representation Learning** Project: Representation learning	**10 ECTS**
2	Courses / lectures	Projekt: Project Representation Learning (8 SWS) yes for final presentations and meetings	-
3	Lecturers	Mischa Dombrowski	

4	**Module coordinator**	Prof. Dr. Bernhard Kainz
5	**Contents**	At the Image Data Exploration and Analysis Lab we offer project topics that are connected to our current research in the fields of medical image processing, machine learning, human-in-the-loop computing, and computer vision. Other than a course with fixed topic, project topics are defined individually. The 10 ECTS project is directed towards students of computer science and medical engineering. Please have a look at our website for an overview. https://www.idea.tf.fau.eu/teaching/open-projects/ Different projects in the area of (deep) representation learning are on offer. These reach from theoretical exploration of new data representation methods to practical evaluation of applications in, e.g., medical image analysis. Furhter example projects will be made available on the website of the Image Data Exploration and Analysis Lab. Students may also propose their own projects, which will be coordinated and refined with the module lead during preliminary discussions.
6	**Learning objectives and skills**	The students work their way into complex software systems and expand them learn to develop and implement solutions independently document the software they have written. We'll start with a project definition phase, followed by literature research, idea outline and implementation phase. Final results will be presented in a mini-symposium and further explained in a short 10-page scientific report. **Module aims** In this module you will have the opportunity to demonstrate independence and originality, to plan and organise a large project over a long period, and to put into practice the knowledge, skills and research methods that you have learnt throughout the course. **Learning outcomes** Upon successful completion of this module, you will have demonstrated your ability to: - apply previously taught knowledge and skills to a substantial problem in Computing or Data Science, as an individual - conduct an independent investigation and apply cutting-edge research, methods and thinking appropriate to the problem - present complex technical material orally to a mixed audience

		- exercise scientific writing skills by way of a substantial written report, summarising your findings **Module syllabus** There will be a small number of supporting meetings that will 1. describe the structure of the project, including expectations, milestones and deliverables, 2. give guidance on writing and presentation skills targeted specifically at individual projects, 3. explain the assessment procedures. The rest of the project involves an independent investigation under the supervision of an academic advisor.
7	**Prerequisites**	You should have very solid programming skills and have knowlege in machine learning, deep learning and computer vision methods.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 240 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 47594	**Research Project on Surgical Robotics** Research project: Surgical robotics	**10 ECTS**
2	Courses / lectures	Praktikum: Research Project on Surgical Robotics (4 SWS)	10 ECTS
3	Lecturers	Prof. Dr. Franziska Mathis-Ullrich Pit Henrich	

4	**Module coordinator**	Prof. Dr. Franziska Mathis-Ullrich
5	**Contents**	At Surgical Planning and Robotic Cognition (SPARC) Laboratory, we focus on various research projects in the field of minimally invasive surgical robotics, cognitive robot-assisted surgery, and assistance systems for the operating room (e.g., augmented reality). Within this scope, applications and systems are developed, which are often (pre-)clinically tested in collaboration with medical partners in order to enable translation of the technologies into practice. Through this research project, students will gain hands-on experience and insight into the use of computer science and engineering in medical robotics and its applications. Depending on the advertised project, this internship will involve working alone or in teams of 2 to 3 students on a task that addresses current research topics at the SPARC lab. Due to the interdisciplinary nature of the field of medical robotics, research projects with a focus on hardware development as well as those with a focus on software development are offered. Details, as well as required prior knowledge, are noted on the respective project announcements.
6	**Learning objectives and skills**	Students • are able to solve a practical problem from the field of medical robotics independently. • understand the underlying medical problem/challenge. • gain practical skills in the use of hardware and software in the field of surgical robotic systems and according measurement and control technology. • are able to specify and implement hardware and software required to solve a given problem. • apply basic knowledge to a problem and develop solution strategies. • are able to solve a problem alone or as part of a team • have knowledge of the phases of a project, time, and resource management. • are confident in the use of software development tools, source code management, and documentation. • are able to convey complex technical content in a scientific presentation.

7	**Prerequisites**	Recommended: basic maths, programming skills, machine learning.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Variable Coursework, Written report in the style of scientific publication, 4-5 pages
11	**Grading procedure**	Variable (100%) Coursework: 85% Written report: 15% both must be passed
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 92413	**Project Assistive Intelligent Robotics**	**10 ECTS**
2	Courses / lectures	No courses / lectures available for this module!	
3	Lecturers	No lecturers available since there are no courses / lectures for this module!	

4	**Module coordinator**	Prof. Dr. Claudio Castellini
5	**Contents**	In the Assistive Intelligent Robotics Lab (AIROB, see https://www.airob.tf.fau.de/) we are interested in translating to rehabilitation ideas, concepts, mechanisms, control systems, interaction strategies and ways to detect a patient's intention. We focus on prostheses, exoskeletons and exo-suits as well as fully fledged robotic arms and virtual reality; we also focus on interactive machine learning, sensors and the signals they provide, the physical attachment of sensors and actuators to the human body, and functional assessment. Somato-sensory feedback is, lastly, of great interest to us. Students will first get a thorough introduction to our topics and a practical hand-on one- or two-weeks course, then work on individual small research topics within this field and develop prototypes to solve the addressed problems.
6	**Learning objectives and skills**	Students will • develop and implement an algorithm for a problem within the field of rehabilitation and assistive robotics which might lead in some circumstances to an improvement to the state-of-the-art, • acquire hands-on experience in an emerging research field, • learn best practices in software development and documentation, • gain first experience in academic writing.
7	**Prerequisites**	Recommended: • some basics in signal processing.
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	Artificial Intelligence Project Bachelor of Science Artificial Intelligence 20242
10	**Method of examination**	Practical achievement Written summary and Powerpoint presentation of the completed tasks in the style of a scientific publication, e.g., as a co-author of an actual publication or as a written report of 4 to 6 pages.
11	**Grading procedure**	Practical achievement (100%) The grade is formed from the Report (50 %) and the Presentation (50 %).
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: ?? h (keine Angaben zum Arbeitsaufwand in Präsenzzeit hinterlegt) Independent study: ?? h (keine Angaben zum Arbeitsaufwand im Eigenstudium hinterlegt)

14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	