Appendix A: Course Schedule

for the study programme Digital Technologies (work-integrated) B.Eng.

Please note: The German version of this document is the legally binding version. The English translation provided here is for information purposes only.

First semester			L	ST	E	P/S	SSS	CP
Module number	Module title	Module ID						
3132	Fundamentals of Business Administration	GBW	2	0	2	0	1	5
3353	Principles of Computer Science	GDI	2	0	1	1	1.5	5
3342	Foundations of Data Science and Information Privacy	GDS	2	0	2	0	1.5	5
3218	Mathematics I	MATH1	2	0	2	0	1	5
3121	Technical English	TCE	2	0	0	2	1	5
							Total CP:	25
Second semester			L	ST	E	P/S	SSS	CP
Module number	Module title	Module ID						
3343	Algorithms and Data Structures	AUDS	2	0	1	1	1	5
3019	Databases	DUD	2	0	1	1	1.5	5
3257	Mathematics II	MATH2	2	0	2	0	1	5
3267	Object-Oriented Programming	OOP	2	0	1	1	1.5	5
3219	Operations Research	MOR	1	0	3	0	1.5	5
							Total CP:	25
Third semester			L	ST	E	P/S	SSS	CP
Module number	Module title	Module ID						
3345	Big Data	BDT	2	0	1	1	1.5	5
3344	Cluster Computing	CLC	2	0	1	1	1	5
3210	Business Process Modelling and IT Systems	GPM	2	0	1	1	1	5
3254	HMI and User Interfaces	HMI	2	0	2	0	1	5
3112	Practical Module I	PX1	0	0	0	0	0	5
3224	Statistics	STAT	2	0	2	0	1	5
							Total CP:	30
Fourth semester			L	ST	E	P/S	SSS	CP
Module number	Module title	Module ID						
3341	Data Mining	DM	2	0	1	1	1	5
3340	Machine Learning	ML	2	0	1	1	1	5
3347	Fundamentals of Physics/Electrical Engineering	PGET	2	0	2	0	1.5	5
3346	Speech and Image Recognition	SUB	2	0	1	1	1	5
3207	Web Technologies	WEB	2	0	1	1	1	5
							Total CP:	25
Fifth semester			L	ST	E	P/S	SSS	CP
Module number	Module title	Module ID						
3216	Business Intelligence	BUI	2	0	1	1	1	5

3122	Practical Module II	PX2	0	0	0	0	0	5
3264	Networking and IoT Solutions	IOT	2	0	1	1	1.5	5
9006	Elective Module: Digital Technologies	WM				0		5
9006	Elective Module: Digital Technologies	WM				0		5
							Total CP:	25

Sixth semester			L	ST	E	P/S	SSS	CP
Module number	Module title	Module ID						
3349	Assistance Systems	ASY	2	0	1	1	1.5	5
3129	Practical Module III	PX3	0	0	0	0	0	5
3259	Safety and Security	SAS	2	0	1	1	1.5	5
9006	Elective Module: Digital Technologies	WM				0		5
9006	Elective Module: Digital Technologies	WM				0		5
							Total CP:	25

Seventh semester			L	ST	E	P/S	SSS	CP
Module number	Module title	Module ID						
3133	Bachelor Thesis	BA	0	0	0	0	0	12
3211	Innovation and Project Management	IPM	2	0	2	0	1	5
3134	Colloquium	KOL	0	0	0	0	0	3
3348	Quality Assurance for AI Systems	QKI	2	0	1	1	1.5	5
							Total CP:	25

Abbreviations of the teaching forms: L = lecture, ST = tuition in seminars, E = exercise, S = seminar, P = practical, SSS = supervised self-study (all data in semester credit hours);
CP = credit points
W/S = winter/summer semester

Elective Modules Digital Technologies									
Module number	Module title	Module ID	W/S	L	ST	E	P/S	SSS	CP
3338	Change Management	CHM	W	2	0	2	0	1	5
3252	Diagnosis and Predictive Maintenance	DPM	W	2	0	2	0	1	5
3339	Digital Business Models and Value Chains	DGW	S	2	0	2	0	1	5
3117	Industrial Control Technology	IST	S	2	0	1	1	1.5	5
3355	Marketing and Technical Sales	MUV	S	2	0	2	0	1	5
3125	Feedback Control Engineering	RTK	S	2	0	1	1	1.5	5
3350	Sensors and Actuators	SUA	W	2	0	2	0	1	5
3351	Social Media and Natural Language Processing	SMNLP	W	2	0	2	0	1	5

Appendix B: Module catalogue

for the study programme Digital Technologies (work-integrated) B.Eng.

Algorithms and Data Structures					AUDS
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3343	150 h	5	2nd sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	54	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

- Students apply the language constructs of the Python programming language to implement small programmes.
- The students know ways of formally describing algorithms and discuss interface agreements as a basis for the reusability of implemented functions.
- Students can name basic search and sorting algorithms as well as fast sorting algorithms, write them down as pseudo code and explain them.
- Students programme basic algorithms as functions in a scripting language (preferably Python) and apply the implemented algorithms to given problems.
- The students write programme scripts for the numerical evaluation of the algorithm runtime and test their self-implemented algorithms with regard to their runtime as a function of the problem size.
- The learners compare the runtime complexity (efficiency) of different algorithms by analysing the algorithm structure and can thus classify the previously numerically determined runtime behaviour into runtime classes.
- Students implement backtracking algorithms and fast sorting methods in a scripting language (preferably Python).
- The students implement their own data structures and data types and test them in the context of given problems.

3 Contents:

- Programming in Python
- Basics and terms for the formal description of algorithms
- Formalisation of interface agreements (pre- and postconditions, agreement of data formats, default behaviour, exceptions)
- Hardware-independent evaluation of the complexity of algorithms (in particular runtime complexity, memory complexity, the concept of the Random Access Machine, Big O notation)
- Simple search and sorting algorithms
- Divide-and-conquer strategies, backtracking problems
- Comparison of iterative and recursive programming methods

	for algorithm implementation • Fast sorting algorithms • Abstract and concrete data types • Graphs and trees • hashing	
4	Forms of teaching: Learning units for self-study, classroom events in the form of exercises and practicals	
5	Participation requirements:	
	Formal:	
	Content:	Knowledge of procedural programming (module "Foundations of Computer Science")
6	Forms of assessment: Written examination or oral examination	
7	Prerequisite for the award of credit points: Module examination pass and course assessment	
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade: according to BRPO	
10	Module coordinator: N. N.	
11	Other information:	
12	Language: German	

Assistance Systems					ASY
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3349	150 h	5	6th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

- The students know the basics of human-machine systems.
- They explain the design rules of ergonomic human-machine interfaces.
- They know the basics of robotics both in the field of robot manipulators and in the field of mobile robotics.
- They calculate kinematic chains for robot manipulators and motion kinematics for mobile robots.
- They compare robotics applications from the fields of industry, service and care, especially from the point of view of interaction between assistive robots and human operators/users.
- They know the basis of computer vision and explain simple algorithms for three-dimensional object recognition; they apply ready-made software implementations of such algorithms to simple visual scenes.
- They know the basics of computer graphics, especially for the presentation of three-dimensional scenes and objects; they use a 3D graphics API to programme the visualisation of simple 3D scenes.
- They explain the basics of augmented and virtual reality.
- They will implement the representation of 3D objects in a virtual reality environment and the representation of 2D and 3D objects in an augmented reality setup.
- They explain the basics of the voice control of technical systems.

3 Contents:

Human-machine systems:

- Human models
- Ergonomic design
- Design rules of human-machine interfaces

Robotics Basics:

- Robot manipulators (kinematics, elastic drives and manipulators)
- Mobile robotics (kinematics, sensor technology)
- Robotics applications (industrial robots, service and care robots)

	Computer Vision: • Principles • Three-dimensional object recognition • Computer graphics • Basics of 3D representation • Augmented Reality • Virtual Reality Voice control of technical systems: • Basics and application examples	
4	Forms of teaching: Learning units for self-study, classroom events in the form of exercises and practicals	
5	Participation requirements:	
	Formal:	
	Content:	• In-depth computer science knowledge • Knowledge of machine learning incl. speech and image recognition • Module "HMI and User Interfaces"
6	Forms of assessment: Written examination or oral examination	
7	Prerequisite for the award of credit points: Module examination pass and course assessment	
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade: according to BRPO	
10	Module coordinator: N. N.	
11	Other information:	
12	Language: German	

Bachelor Thesis					BA
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3133	360 h	12	7th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	SCH	0	h	360	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	0	SCH	0	h	0	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	0	SCH	0	h	0	h

2	Learning outcomes/competences:	
	After successfully completing the bachelor thesis, students are able to independently work on and appropriately present a practice-oriented task from their special subject area, both in the subject-specific details and in the interdisciplinary contexts, using scientific methods within a specified period of time.	
3	Contents:	
	The bachelor thesis is an independent scientific work from the subject area of the respective study programme with a description and explanation of its solution. It can be derived from current research projects at the university or from operational problems with an engineering character. It can also be determined by an empirical investigation or by conceptual or design tasks or by an evaluation of existing sources. The different forms can be combined.	
4	Forms of teaching:	
	Written composition with faculty tutoring	
5	Participation requirements:	
	Formal:	-
	Content:	Coordinated topic from the student's special subject area
6	Forms of assessment:	
7	Prerequisite for the award of credit points:	
8	Application of the module (in the following study programmes)	
	Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics /Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	N. N.	
11	Other information:	
	-	
12	Language:	
	German	

Big Data					BDT
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3345	150 h	5	3rd sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

- Students present the history and basic concepts of "Big Data".
- They know the basic principles of noSQL databases.
- They distinguish noSQL databases based on the CAP theorem and the underlying data model.
- They know the theoretical basics of: document-oriented databases, graph databases, key-value databases, object databases and column-oriented databases
- They use the databases mentioned in the previous point and apply them in practice.
- They distinguish between the different types of noSQL databases based on their scope of application and assess when which type of noSQL database should be used.
- In particular, they design benchmarks to compare database systems in order to achieve the best possible performance in practice.
- They know the concept of the data warehouse in theory and practice.
- They design a data warehouse for the integration of different data sources as a preparatory step for data mining.
- They explain the basics of federated information systems and analyse how they differ from data warehouses.
- They know the importance of data management in the company and explain central requirements and measures for a functioning data management system.

3 Contents:

- History and basic concepts of "Big Data"
- Introduction to noSQL databases
- Differentiation of noSQL databases according to CAP theorem and data model
- Concrete noSQL database types: document-oriented databases, graph databases, key-value databases, object databases, column-oriented databases
- Benchmarking of database systems
- Data warehouse
- Federated information systems
- Basics of data management

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5	Participation requirements:	
	Formal:	
	Content:	Modules “Databases”, "Foundations of Computer Science" and "Object-Oriented Programming"
6	Forms of assessment: Written examination or oral examination	
7	Prerequisite for the award of credit points: Module examination pass and course assessment	
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade: according to BRPO	
10	Module coordinator: N. N.	
11	Other information:	
12	Language: German	

Business Intelligence					BUI
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3216	150 h	5	5th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	64	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students:

- are familiar with the central methods and requirements of controlling operational processes as well as the essential requirements and action strategies associated with the management of business processes.
- have the holistic view of the problem that is necessary in this context and are able to understand the many interactions in the different areas of business administration in a way that is appropriate to the problem.

3 Contents:

- Basics of logistics controlling (strategic, tactical, operational)
- Derivation of key performance indicators for the quality of operational processes
- Indicator systems in practice
- Recording and reporting of logistics services, revenues and calculation of logistics costs
- Data sources in the company (e.g. ERP) and evaluation tools (e.g. business warehouse)
- Extract, Transform, Load (ETL) processes
- Reporting and dashboard applications
- Data discovery and business intelligence (e.g. with SAP BO)
- Project-related logistics controlling
- Integrating approaches for the design of logistics controlling:
- Supply Chain Operations Reference Model, Balanced Scorecard

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	-
Content:	-

6 Forms of assessment:

Term paper, written examination, project work or oral examination

7 Prerequisite for the award of credit points:

Module examination pass and course assessment

8 Application of the module (in the following study programmes)

Digital Logistics (practice integrated) B.Eng. and Digital Technologies (practice integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10	Module coordinator: Prof. Dr. rer. oec. Pascal Reusch
11	Other information: -
12	Language: German

Change Management					CHM
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3338	150 h	5	5th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

The students know the change management aspects of corporate development.

They understand how strategic realignments can be implemented in organisations.

Students are able to analyse corporate situations in change and define change strategies. They have insights into leadership behaviour in change situations.

The students know and understand the phase models of change management, according to which change projects are structured and implemented, and on the basis of which typical behaviour patterns are explained

Students will be able to apply systemic analysis and diagnosis approaches to determine the need for action and to prepare e.g. change coalitions and communication measures.

The students know the essential methods and instruments that e.g. facilitate the handling of resistance, conflicts and power games or which, for example, set up new structures and processes.

They will acquire the skills to identify quality criteria for successful change projects and to derive change measures for them.

3 Contents:

- Shaping organisational change: Phase models of corporate development, fields of action of change management, conceptual approaches to change management
- Procedures and techniques for planning, steering and controlling revolutionary and evolutionary change processes
- Stakeholder analysis
- Ethical reflection of change management issues in the corporate development process
- Dealing with resistance / exercises to develop social skills for managers in change situations
- Key figures / change controlling
- Process Evaluation / Continuous Improvement Process and Lessons Learned

4	Forms of teaching:	
	Learning units for self-study, classroom sessions in the form of exercises	
5	Participation requirements:	
	Formal:	
	Content:	Module "Fundamentals of Business Administration"
6	Forms of assessment:	
	Term paper or written examination	
7	Prerequisite for the award of credit points:	
	Module examination pass	
8	Application of the module (in the following study programmes)	
	Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	N. N.	
11	Other information:	
12	Language:	
	German	

Cluster Computing					CLC
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3344	150 h	5	3rd sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	54	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

- Students explain the theoretical foundations of parallel computing (parallel computer architectures, Amdahl's law, race conditions, design patterns for parallel computing, etc.).
- They design and implement distributed applications using MPI and OpenMP.
- They explain the concept of Hadoop.
- They implement simple data analyses on a Hadoop cluster.
- They know the theoretical basics of cloud computing and compare the possibilities of different commercial platforms.
- They implement data analysis workflows in the cloud.

3 Contents:

- Theoretical foundations of parallel computing (parallel computing architectures, Amdahl's law, race conditions, design patterns for parallel computing, etc.)
- Distributed computing with MPI
- Parallel computing on individual SMP systems (e.g. with OpenMP)
- Parallel computing on Hadoop clusters (Map-Reduce, etc.)
- Cloud computing in theory and practice

4 Forms of teaching:

Learning units for self-study, classroom events in the form of exercises and practicals

5 Participation requirements:

Formal:	
Content:	Modules “Foundations of Computer Science” and “Object-Oriented Programming” Basic knowledge of databases

6 Forms of assessment:

Written examination or oral examination

7 Prerequisite for the award of credit points:

Module examination pass and course assessment

8 Application of the module (in the following study programmes)

Digital Technologies (work-integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10 Module coordinator:

N. N.

11	Other information:
12	Language: German

Data Mining					DM
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3341	150 h	5	4th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	54	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

- The students explain the history and basis of data mining and establish the relationship to its practical application possibilities.
- They apply suitable methods to visualise both small and large data sets and the interrelationships within them in an instructive way ("visual analytics").
- They use correlation analysis and regression to detect relationships between data series in multidimensional data sets.
- They are proficient in common dimensional reduction techniques.
- They can find clusters of related data points in multi-dimensional data sets and assess their quality.
- They detect common patterns in data sets and use graph-based methods.
- They have basic knowledge of time series analysis and apply simple procedures from this area in a targeted manner.
- They have a comprehensive overview of data mining methods and can assess which methods should be used in which application scenarios.
- They design data mining workflows.

3 Contents:

- Basics of data mining
- Visualisation of data (especially also for the visualisation of very large amounts of data; "visual analytics")
- Correlation analysis and regression
- Dimension reduction
- Clustering methods
- Frequent pattern mining
- Graph-based methods
- Basics of time series analysis
- Data mining workflows

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	
Content:	• Content of the “Mathematics” and “Statistics” modules • Advanced programming skills in Python

6	Forms of assessment: Written examination or oral examination
7	Prerequisite for the award of credit points: Module examination pass and course assessment
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information:
12	Language: German

Databases					DUD
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3019	150 h	5	2nd sem.	Annual (Summer)	1 semester

	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
1	Lecture	60 students	2	SCH	0	h	68	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	34	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

Students:

- acquire basic knowledge about the architecture, functioning and use of database systems and know the principles of the organisation of a database system
- acquire knowledge about modern (object-oriented) and classic data modelling including the meaning of normalisation rules
- are able to perform a complete relational database design, starting from a requirements specification are proficient in standard SQL to perform simple and complex queries, as well as change operations.
- gain the ability to evaluate and select database technologies
- can plan and implement database projects and develop a modern database application

3 Contents:

- Introduction to database concepts and database technologies (data modelling, normalisation theory, database language SQL)
- Basics of database systems (database design, database definitions, database queries)
- Data Manipulation Language (DML, German "Datenverarbeitungssprache"), Data Definition Language (DDL, German “Datenbeschreibungssprache"), Data Control Language (DCL, German “Datenaufsichtsprache")
- Efficiency of SQL queries, index structures
- Authorisation concepts

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	-
Content:	-

6 Forms of assessment:

Term paper, written examination, combined examination, project work, oral examination or examination accompanying the course

7 Prerequisite for the award of credit points:

Module examination pass and course assessment

8 Application of the module (in the following study programmes)

	Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering and Management (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: Dr. rer. nat. Sabrina Proß
11	Other information: -
12	Language: German

Diagnosis and Predictive Maintenance					DPM
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3252	150 h	5	5th or 7th semester	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

The students know different monitoring models and can describe them. They have acquired basic knowledge of physical and discrete-event modelling and can use the modelling methods to diagnose faults and misbehaviour. They understand the different diagnostic approaches and can use them for specific applications. They have acquired knowledge of the theories of parameter estimation, vibration analysis, data-based analysis of measurement series, etc. and can establish connections between the methods. They develop algorithms for signal analysis and pattern classification and can explain their solutions in technical discussions and justify their approach. They create parity equations and symptom tables and test them on simple faulty processes.

3 Contents:

- Signal-based diagnosis, limit value/trend monitoring
- Trajectory monitoring and plausibility check
- Model-based diagnosis
- Analysis of signal models and process models
- Correlation and spectral analysis
- Parameter estimation
- Parity equations
- Condition monitoring
- Vibration analysis
- Predictive maintenance
- Data-based analysis
- Presentation of selected data mining challenges: Classification, clustering etc.

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	-
Content:	-

6 Forms of assessment:

Term paper, written examination, project work or oral examination

7 Prerequisite for the award of credit points:

Module examination pass

8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng. and Product-Service Engineering (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information: -
12	Language: German

Digital Business Models and Value Chains					DGW
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3339	150 h	5	6th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students can evaluate the specifics of classic business models and digital business models, break them down into their essential components, and also combine mixed models themselves.

Students can analyse and evaluate operational business processes and optimise them, especially with regard to the interfaces between organisations.

Students explore successful examples of digital business models and can assess success factors.

The students can evaluate value chains with regard to their most important performance parameters and derive optimisation proposals, especially on the basis of digital technologies.

3 Contents:

Fundamentals of value creation – generating customer benefits

Globalisation and digitalisation as drivers of change processes

Diversification of value creation processes and specialisation in core competencies

Integration of a wide variety of partners in a value chain to satisfy consumer needs

Digital transformation of classic products and services or creation of new virtual services

Success stories of digital business models – Google, Amazon, Facebook, Uber...

Communication concepts between partners in the value chain (from telephone to EDI)

E-business – mapping existing processes and products into electronic form to benefit time, quality and costs.

Finding partners (sourcing concepts)

	Establishing long-term cooperation (contract design and confidence building) Loose business cooperations (marketplace concepts for dynamic collaboration) Risk management of more complex value creation networks (agility and resilience) Flexible, decentralised and efficient control of inter- and intra-organisational core processes	
4	Forms of teaching: Self-study units, exercises and practicals in the form of face-to-face events	
5	Participation requirements:	
	Formal:	
	Content:	Module "Fundamentals of Business Administration"
6	Forms of assessment: Term paper or written examination	
7	Prerequisite for the award of credit points: Module examination pass	
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade: according to BRPO	
10	Module coordinator: Prof. Dr. rer. oec. Pascal Reusch	
11	Other information:	
12	Language: German	

Business Process Modelling and IT Systems					GPM
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3210	150 h	5	3rd sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	64	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students:

- structure and evaluate the specific mode of operation of integrated standard software (ERP software).
- design and model processes in the company with the help of modern software architectures (e.g. SOA and BPMS).
- analyse processes and requirements of companies for the use, operation and maintenance of integrated software systems (adaptation options, interfaces to other IT systems, etc.)

3 Contents:

- Process modelling and data modelling using modelling tools (e.g. ARIS)
- Evaluation of concepts of integrated data processing
- Drafting reference models for designing the data, process and function models (e.g. Aachen PPS model)
- Analysis of ERP systems (architecture, structuring, database models, HANA)
- Overview of the core modules and applications of ERP systems in the process: e.g. order to cash process)

Application-oriented use cases are used to demonstrate how business processes can be implemented consistently and across software modules.

4 Forms of teaching:

Learning units for self-study, classroom events in the form of exercises and practicals

5 Participation requirements:

Formal:	-
Content:	-

6 Forms of assessment:

Term paper, written examination, project work or oral examination

7 Prerequisite for the award of credit points:

Module examination pass and course assessment

8 Application of the module (in the following study programmes)

Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng. and Industrial Engineering and Management (work-integrated) B.Eng.

9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: Prof. Dr.-Ing. Jörg Nottmeyer
11	Other information: -
12	Language: German

Fundamentals of Business Administration					GBW
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3132	150 h	5	1st or 3rd semester	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

The students know the basic organisational structures and the optimisation tasks of companies as well as the basic principles and success criteria of economic action. This enables them to classify their own engineering activities in the operational and business context and to assess and control the economic consequences/effects of their activities. In this sense, the module provides the basic business knowledge and the basic structures for interdisciplinary thinking and action.

3 Contents:

- Classification, development and basic concepts of business administration
- Basic principles of economic action
- Overview of the most important business functional areas at the level of goods management and finance as well as the cross-functional areas (materials management, production, sales, investment and financing, business accounting (annual financial statements, cost accounting))
- Corporate goals and
- Corporate key figures/key performance indicator systems
- Forms of corporate law and corporate affiliations

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	-
Content:	-

6 Forms of assessment:

Term paper, written examination, project work or oral examination

7 Prerequisite for the award of credit points:

Module examination pass

8 Application of the module (in the following study programmes)

Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng. and Product Service Engineering (work-integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10 Module coordinator:

Economist Ulrike Franke

11	Other information: -
12	Language: German

Foundations of Computer Science					GDI
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3353	150 h	5	1st sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

After successful completion of the module, students master the terminology of computer science and have basic knowledge of the functioning of computer systems and computer architectures. The students know selected methods for the description and evaluation of algorithms. They can structure simple information technology problems and develop suitable solutions, as well as justify and defend them. Students have basic knowledge and initial experience in the implementation of algorithms in the programming language C.

3 Contents:

Introduction to Computer Science:

- Terms
- Definitions
- Number systems
- Representation of numbers and characters in the computer
- Methods for describing algorithms with flow charts, Nassi-Shneiderman diagram and pseudo code
- Methods for evaluating the complexity of algorithms

Basics of computer architecture:

- Basic structure of processors
- Instruction cycle in microprocessors
- Memory hierarchy
- Bus systems

Programming in C:

- Conditional instructions
- Loops
- Functions
- Arrays
- Pointers
- Structs
- Working with files

Selected algorithms:

- Sorting algorithms (e.g. bubble sort and quick sort)
- Search algorithms (e.g. binary search)

4	Forms of teaching:	
	Learning materials for self-study, classroom sessions of exercises and practicals	
5	Participation requirements:	
	Formal:	
	Content:	
6	Forms of assessment:	
	Term paper, written examination, project work or oral examination	
7	Prerequisite for the award of credit points:	
	Module examination pass	
8	Application of the module (in the following study programmes)	
	Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng. and Product Service Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	Prof. Dr.-Ing. Christian Stöcker	
11	Other information:	
12	Language:	
	German	

Foundations of Data Science and Information Privacy					GDS
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3342	150 h	5	1st sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	54	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

- The students know the historical development of data science.
- They explain current problems in the field of data science and know the associated job descriptions.
- They explain common data analysis workflows.
- They search for further information in scientific databases (especially journal and conference publications).
- They write short papers that meet the formal requirements of academic writing.
- They give short presentations and use common presentation techniques.
- They explain and evaluate the most important current ethical and legal requirements in the field of data protection.
- They compare technical-organisational measures to implement these requirements.

3 Contents:

- Historical development of data science
- Current problems in the field of data science
- Job profiles in the field of data science
- First look at data analysis workflows
- Scientific research
- Introduction to scientific writing
- Presentation techniques
- Introduction to the topic of information privacy: ethical and legal requirements (national and international law)
- Overview of technical and organisational measures to implement the information privacy requirements

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	
Content:	None

6 Forms of assessment:

Term paper, combination examination or oral examination

7 Prerequisite for the award of credit points:

Module examination pass

8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information:
12	Language: German

HMI and User Interfaces					HMI
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3254	150 h	5	3rd sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

The students know the principles of human information processing. They can explain and apply methods, guidelines and standards for the design of user interfaces. They are able to implement design principles with the corresponding methods and thus develop user interfaces. They design and model user interfaces and can test them with respect to applicability. They are familiar with the software development process and use it to develop interfaces for operating and interacting with machines.

3 Contents:

- Human information processing (models, physiological and psychological foundations, human sensing, action processes)
- Design basics and design methods
- Basics of input and output for computers, embedded systems and mobile devices
- Principles, guidelines and standards for the design of user interfaces
- Basics for the design of user interfaces (text dialogues and forms, menu systems, graphical interfaces, interfaces in the WWW, audio dialogue systems, haptic interaction, gestures)
- Methods for modelling user interfaces (abstract description of interaction, as part of requirements analysis and the software design process)
- Development of user interfaces in an object-oriented programming language

4 Forms of teaching:

Learning units for self-study, classroom sessions in the form of exercises

5 Participation requirements:

Formal:	-
Content:	Modules "Foundations of Computer Science" and "Object-Oriented Programming"

6 Forms of assessment:

Term paper, written examination, project work or oral examination

7 Prerequisite for the award of credit points:

Module examination pass

8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng. and Product-Service Engineering (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information: -
12	Language: German

Industrial Control Technology					IST
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3117	150 h	5	4th or 6th semester	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

After successful completion of the course, the students have a basic knowledge of the essential components of an automation system and can select and use them in a solution-oriented manner. They know how conventional and PC-based controls work and can program these controls with different programming languages. They know the basics of bus systems and can name different bus systems and their areas of application. They can formally describe controls as discrete systems by means of automata, Petri nets and UML state diagrams and use these models for the methodical design of logic controllers, sequence controllers, control systems and diagnostic units.

3 Contents:

Introduction to control technology

- Terms
- Definitions

Sensors and actuators

- Standard sensors and their application (inductive, optical)
- Basics of FI and servo technology, pneumatics
- Safety functions (ST0; SS1; SS2; SOS...)

Bus technology

- Basics of industrial communication
- Comparison of different bus systems and their areas of application

Design and structures of industrial controls

- PLC and PC-based control
- Information processing

Structured programming according to IEC 61131

- Graphics- and text-based programming languages
- Basics of object-oriented PLC programming

Linkage controls

- Description of discrete systems by deterministic automata
- Model-based control design
- Practical implementation in ST and UML state diagram

	Sequence controls and schedule controls • Description of discrete systems • Model-based design and practical implementation of the control system Error management • Fault diagnosis and detection • Preventive diagnosis
4	Forms of teaching: Learning units for self-study, classroom events in the form of exercises and practicals
5	Participation requirements: Formal: Content:
6	Forms of assessment: Written exam, project work or oral exam
7	Prerequisite for the award of credit points: module examination pass and course assessment
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering and Management (work-integrated)B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: Prof. Dr.-Ing. Thomas Freund
11	Other information:
12	Language: German

Innovation and Project Management					IPM
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3211	150 h	5	3rd/4th/5th or 7th sem.	each semester	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students:

- are prepared to lead product development and innovation projects and teams to success in terms of holistic and strategically oriented project management (also including agile methods).
- understand the basics of project management and can use the elementary technical vocabulary.
- can explain the most important instruments of project management.
- are able to lead/manage a project in a given process-organisational project organisation.
- are able to develop and specifically use control options for different project phases (controlling of the degree of completion, cost controlling).
- can explain the specifics of team building and project management.
- can carry out the moderation of team meetings projects.
- know instruments of IT-supported project management.
- can explain the importance of corporate objectives and are able to distinguish between different management cultures.
- can name essential aspects of industrial property protection.

3 Contents:

- Basics of project management (terms/methods/instruments)
- Project phase models and planning systems (project preparation, project planning, project implementation, project completion)
- Agile project management
- Forms of project organisation
- Innovation and change management, self-management
- Project planning (project structure plan/cost plan/resource plan/schedule)
- Project documentation/ project controlling
- Risk management
- Special features of use of methods in innovation projects

	(Strategic preparation / initiation, planning, monitoring and control of innovation projects) • Leading project and innovation teams (social structures, special communication situations in projects, real and virtual project work, problem analysis and concepts for action) • Stakeholder management (factors influencing the successful management of projects) • Methods of idea generation (creativity techniques etc.) • Trainings and workshops on selected technical examples • Basic aspects of industrial property protection
4	Forms of teaching: Learning units for self-study, classroom sessions in the form of exercises
5	Participation requirements: Formal: - Content: -
6	Forms of assessment: Term paper, written examination, project work or oral examination
7	Prerequisite for the award of credit points: Module examination pass
8	Application of the module (in the following study programmes) Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: Prof. Dr.-Ing. Michael Fahrig
11	Other information: -
12	Language: German

Colloquium					KOL
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3134	90 h	3	7th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	SCH	0	h	90	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	0	SCH	0	h	0	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	0	SCH	0	h	0	h

2	Learning outcomes/competences:	
	In the colloquium, students demonstrate that they are able to present the results of the bachelor thesis, its subject-specific foundations, its interdisciplinary connections and its extra-curricular references orally and justify them independently. Students can critically question the results of their work and are able to assess their significance for practice.	
3	Contents:	
	The colloquium complements the bachelor thesis and is to be assessed independently. Content of the thesis Disputation on topics such as: the preparation of the thesis and the issues that arose in the context of the thesis.	
4	Forms of teaching:	
	Oral examination	
5	Participation requirements:	
	Formal:	All modules of the study programme must be successfully completed. The bachelor thesis must be successfully completed.
	Content:	Treatment of the bachelor thesis
6	Forms of assessment:	
	Oral examination	
7	Prerequisite for the award of credit points:	
8	Application of the module (in the following study programmes)	
	Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics /Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	N. N.	
11	Other information:	
	-	
12	Language:	
	German	

Marketing and Technical Sales					MUV
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3355	150 h	5	6th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students develop an understanding of the importance of strategic planning for the market success of a company operating in a technical environment. They are able to develop marketing and sales concepts, especially for the b2b business, and to react to market changes with alternative concepts. They possess functional analysis and planning skills that enable them to critically reflect on current market events and developments and to shape them in a goal-oriented manner.
Students have basic knowledge of the design options of product and price management, which form the basis for successful sales. Building on this, they acquire the competence to develop structures and concepts for the distribution of technical products and to be able to apply them throughout the entire life cycle.

3 Contents:

- Internal analysis techniques and market research
- Product policy in the individual product life cycle phases
- Instruments and strategies of contracting policy/pricing policy
- Basics and special features of b2b distribution
- Forms of distribution, distribution planning and organisation
- Sales and customer relationship management
- Legal basis of distribution (drafting of contracts, public law, etc.).
- Basic instruments/key figures of sales controlling

4 Forms of teaching:

Lecture notes, seminar-based teaching, exercises, case studies

5 Participation requirements:

Formal:	None
Content:	None

6 Forms of assessment:

Written exam, project work or oral exam

7 Prerequisite for the award of credit points:

Module examination pass

8 Application of the module (in the following study programmes)

Digital Technologies (work-integrated) B.Eng. and Industrial Engineering and Management (work-integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10	Module coordinator: Prof. Dr. rer. pol. Hildegard Manz-Schumacher
11	Other information: Literature will be announced before the start of the course.
12	Language: German

Machine Learning					ML
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3340	150 h	5	4th or 6th semester	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	54	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

- The students explain the history and basics of machine learning and establish the relationship to its practical applications.
- They master the use of common dimension reduction and feature selection methods in practical application.
- They classify data using classification methods from statistical learning theory (such as support vector machines) and from the field of artificial neural networks. They also use decision trees or discriminant analysis for this purpose.
- They use artificial neural networks to learn mappings between arbitrary input and output data (also for time series).
- They know different methods for parameter determination in artificial neural networks and use them in a targeted manner.
- They explain evolutionary algorithms and apply them.
- They have a comprehensive overview of machine learning methods and can assess which methods should be used in which application scenarios.
- They develop workflows for machine learning.

3 Contents:

- Foundations of machine learning
- Data preprocessing
- Dimension reduction and feature selection
- Statistical learning theory and kernel methods
- Classification (support vector machines, decision trees, discriminant analysis, etc.)
- Artificial neural networks (self-organising maps, multi-layer perceptrons, recurrent topologies, extreme learning machines, reservoir computing, etc.)
- Method for parameter determination in artificial neural networks
- Evolutionary algorithms
- Workflows in machine learning
- Practical application examples from industry and the corporate world

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5	Participation requirements:	
	Formal:	
	Content:	• Content of the “Mathematics” and “Statistics” modules • Advanced programming skills in Python
6	Forms of assessment: Written examination or oral examination	
7	Prerequisite for the award of credit points: Module examination pass and course assessment	
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng. and Product-Service Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade: according to BRPO	
10	Module coordinator: N. N.	
11	Other information:	
12	Language: German	

Mathematics I					MATH1
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3218	150 h	5	1st sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

The students are familiar with the mathematical working method and have mastered the basic terms and methods from the areas of analysis and linear algebra, which they can also apply to practice-oriented problems from technology, natural science and economics.

3 Contents:

- General basics (set theory, inequalities, propositional logic, methods of proof)
- Functions of one variable (limit and continuity, polynomial functions, rational functions, trigonometric functions, exponential function, logarithm function)
- Differential calculus for functions of one variable (differentiability, derivation rules, applications)
- Linear algebra (vectors, matrices, determinants, systems of linear equations, eigenvalues and eigenvectors)

4 Forms of teaching:

Learning units for self-study, classroom sessions in the form of exercises

5 Participation requirements:

Formal:	-
Content:	-

6 Forms of assessment:

Written examination, combined examination, oral examination or examination during the course

7 Prerequisite for the award of credit points:

Module examination pass

8 Application of the module (in the following study programmes)

Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics /Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10 Module coordinator:

Dr. rer. nat. Sabrina Proß

11 Other information:

-

12	Language: German

Fundamentals of Physics/Electrical Engineering					PGET
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3347	150 h	5	4th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	54	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

Physics:
The students have basic knowledge of the fundamental physical laws of nature, especially in the areas of mechanics, oscillations and waves, thermodynamics, electricity and magnetism. They can systematically apply basic physical principles to technical questions and independently develop solutions.

Electrical engineering:
The students explain the physical basics of electrical engineering. They name the most important electrical components and explain their basic properties. They master Kirchhoff's rules and use them to analyse elementary circuits and complex electrical networks. They determine voltage and current curves on electrical components with the aid of complex calculation.

3 Contents:

Physics:

- Units and physical quantities
- Mechanics: Kinematics (translation and rotation), dynamics, Newton's axioms and their applications, energy and work, momentum, angular momentum, ..
- Vibrations and waves
- Thermodynamics
- Electricity and magnetism: electric field (discrete / continuous charge distributions), electric potential, capacitance, direct current circuits, alternating current circuits, magnetic field, magnetic inductance, electromagnetic waves

Electrical engineering:

- Atomic model, electrical conductivity, conduction effect in metals, resistance, drift velocity
- Ideal and real voltage sources, voltage and current at ohmic resistors, resistors in series and parallel, energy and power, temperature behaviour of ohmic resistors
- Kirchhoff's rules, elementary circuits
- Linear two-pole circuits (capacitor, inductance)
- Complex calculation (voltage and current curves, complex resistances of capacitor and coil)
- Systematic network analysis/calculation

4	Forms of teaching:	
	Learning units for self-study, classroom sessions in the form of exercises	
5	Participation requirements:	
	Formal:	
	Content:	Mathematical basics
6	Forms of assessment:	
	Written examination or oral examination	
7	Prerequisite for the award of credit points:	
	Module examination pass	
8	Application of the module (in the following study programmes)	
	Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	N. N.	
11	Other information:	
12	Language:	
	German	

Mathematics II					MATH2
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3257	150 h	5	2nd sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students:

- can deepen their knowledge in the area of calculus.
- master the essential principles of integral calculus and differential calculus for functions of several variables.
- have an overview of the methods for the analytical solution of ordinary differential equations and systems of differential equations and can apply these to practice-oriented problems.

3 Contents:

- Complex numbers (definition and representation, complex calculus)
- Integral calculus for functions of one variable (fundamental theorem of differential and integral calculus, integration rules, integration methods, improper integrals, applications)
- Differential calculus for functions of several variables (functions of several variables, partial differentiation)
- Ordinary differential equations (differential equations of the 1st order, linear differential equations of the 2nd or nth order with constant coefficients, systems of linear differential equations)

4 Forms of teaching:

Learning units for self-study, classroom sessions in the form of exercises

5 Participation requirements:

Formal:	-
Content:	- Modules: 3218 Mathematics I;

6 Forms of assessment:

Written examination, combined examination, oral examination or examination during the course

7 Prerequisite for the award of credit points:

Module examination pass

8 Application of the module (in the following study programmes)

Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering and Management (work-integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10	Module coordinator: Dr. rer. nat. Sabrina Proß
11	Other information: -
12	Language: German

Object-Oriented Programming					OOP
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3267	150 h	5	2nd sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

After successful completion of the module, the students have an understanding of object-oriented programming and its distinction from structured programming. They can analyse concrete problems from IT and design and implement suitable solutions in the programming language C++. The students have an overview of selected design patterns and can evaluate and implement their application in given problems. The students have gained knowledge about selected models of the UML and can apply it.

3 Contents:

Introduction to object-oriented programming:

- Fundamental concepts
- Differences between procedural and object-oriented programming

Programming in C++:

- Classes
- Objects and methods
- Operators and operator overloading
- Inheritance
- Templates
- Error handling

Software development:

- Design patterns
- Waterfall model, V-model
- UML (e.g. class diagram and sequence diagram)
- Unit tests

4 Forms of teaching:

Learning letters for self-study, classroom events in the form of exercises and practicals.

5 Participation requirements:

Formal:	
Content:	Structured programming (ideally with C), general informatics basics

6 Forms of assessment:

Term paper, written examination, project work or oral examination

7	Prerequisite for the award of credit points: Module examination pass
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng. and Product-Service Engineering (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: Prof. Dr.-Ing. Christian Stöcker
11	Other information:
12	Language: German

Operations Research					MOR
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3219	150 h	5	2nd sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	1	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	3	SCH	24	h	46	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

Students:

- can apply operations research methods and models in a situation-appropriate manner.
- are able to solve relevant real-world problems from the field of economics and, in particular, logistics with the help of suitable models and methods of operations research, or to develop a solution
- to provide support for decision-making.

3 Contents:

- Introduction to Operations
- Research Models in Operations Research
- Subfields of Operations Research
- Linear Optimisation
- Fundamentals of Graph Theory
- Transport Problems
- Integer optimisation problems (pure-integer linear optimisation problems, knapsack problems)
- Combinatorial optimisation problems (assignment problems, round trip problems, postman problems, route planning problems, machine allocation problems, location problems)
- Dynamic optimisation (batch size planning)

4 Forms of teaching:

Learning units for self-study, classroom sessions in the form of exercises

5 Participation requirements:

Formal:	-
Content:	- Modules: 3218 Mathematics I;

6 Forms of assessment:

Written examination, combination examination, project work, oral examination or examination during the course

7 Prerequisite for the award of credit points:

Module examination pass

8 Application of the module (in the following study programmes)

Digital Logistics (work-integrated) B.Eng. and Digital Technologies (work-integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10	Module coordinator: Dr. rer. nat. Sabrina Proß
11	Other information: -
12	Language: German

Practical Module I					PX1
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3112	150 h	5	3rd sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	SCH	0	h	150	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	0	SCH	0	h	0	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	0	SCH	0	h	0	h

2	Learning outcomes/competences:	
	Students acquire and deepen knowledge and skills specific to the study programme. For this purpose, individual problems are worked on holistically and under practical conditions during the work term at the company and solution options are developed independently. In addition to the professional competence, the students acquire the ability of working scientifically and successively develop it further.	
3	Contents:	
	The topics to be worked on must be related to engineering science and be oriented towards the module contents of the curriculum. The topic is agreed between the student, the supervisor in the company and the examiner at the university of applied sciences.	
4	Forms of teaching:	
	Work-related module	
5	Participation requirements:	
	Formal:	-
	Content:	-
6	Forms of assessment:	
	Term paper	
7	Prerequisite for the award of credit points:	
	Module examination pass	
8	Application of the module (in the following study programmes)	
	Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	Prof. Dr.-Ing. Andrea Kaimann	
11	Other information:	
	-	
12	Language:	
	German	

Practical Module II					PX2
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3122	150 h	5	5th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	SCH	0	h	150	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	0	SCH	0	h	0	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	0	SCH	0	h	0	h

2	Learning outcomes/competences:	
	Students acquire and deepen knowledge and skills specific to the study programme. For this purpose, individual problems are worked on holistically and under practical conditions during the work term at the company and solution options are developed independently. In addition to the professional competence, the students acquire the ability of working scientifically and successively develop it further.	
3	Contents:	
	The topics to be worked on must be related to engineering science and be oriented towards the module contents of the curriculum. The topic is agreed between the student, the supervisor in the company and the examiner at the university of applied sciences.	
4	Forms of teaching:	
	Work-related module	
5	Participation requirements:	
	Formal:	Module examination pass in Practical Module I
	Content:	-
6	Forms of assessment:	
	Term paper	
7	Prerequisite for the award of credit points:	
	Module examination pass	
8	Application of the module (in the following study programmes)	
	Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	Prof. Dr.-Ing. Andrea Kaimann	
11	Other information:	
	-	
12	Language:	
	German	

Practical Module III					PX3
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3129	150 h	5	6th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	0	SCH	0	h	150	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	0	SCH	0	h	0	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	0	SCH	0	h	0	h

2	Learning outcomes/competences:	
	Students acquire and deepen knowledge and skills specific to the study programme. For this purpose, individual problems are worked on holistically and under practical conditions during the work term at the company and solution options are developed independently. In addition to the professional competence, the students acquire the ability of working scientifically and successively develop it further.	
3	Contents:	
	The topics to be worked on must be related to engineering science and be oriented towards the module contents of the curriculum. The topic is agreed between the student, the supervisor in the company and the examiner at the university of applied sciences.	
4	Forms of teaching:	
	Work-related module	
5	Participation requirements:	
	Formal:	Module examination pass in Practical Module II
	Content:	-
6	Forms of assessment:	
	Term paper	
7	Prerequisite for the award of credit points:	
	Module examination pass	
8	Application of the module (in the following study programmes)	
	Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics /Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	Prof. Dr.-Ing. Andrea Kaimann	
11	Other information:	
	-	
12	Language:	
	German	

Quality Assurance for AI Systems					QKI
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3348	150 h	5	7th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

- The students know the tasks and objectives of quality management systems in the company.
- They explain and compare the tools and procedures of quality planning, control, inspection and improvement.
- They explain the industry standards and certification measures for the functional safety of technical systems.
- They discuss and analyse technical and organisational measures for achieving functional safety.
- They apply strategies and frameworks for systematic testing to validate machine-learned models so that they meet the criteria for functional safety in technical systems or general quality criteria.
- They know interpretable models in machine learning and use them where it is necessary for reasons of functional safety or general validation.
- They design process models in data mining that are oriented towards the goal of model-accompanying verification and validation.

3 Contents:

Foundations of quality assurance and management:

- Tasks and objectives of quality management systems in companies
- Terms and definitions
- Tools and procedures for quality planning, control, inspection and improvement

Fundamentals of functional safety in technical systems:

- Industry standards, certification
- Technical-organisational measures

Validation of machine-learned models:

- Strategies and frameworks for systematic testing

Interpretable models in machine learning

- Theoretical foundations
- Application areas

Procedure models in data mining with model-accompanying verification and validation

	• Design of process models • Data mining workflows with model-accompanying verification and validation
4	Forms of teaching: Learning units for self-study, classroom events in the form of exercises and practicals
5	Participation requirements: Formal: — Content: All modules on data mining and machine learning in the DTG study programme
6	Forms of assessment: Written examination or oral examination
7	Prerequisite for the award of credit points: Module examination pass and course assessment
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information:
12	Language: German

Feedback Control Engineering					RTK
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3125	150 h	5	4th/5th/6th sem.	each semester	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

After successful completion of the course, the students will be able to assign the basics from the field of control technology. The students are able to recognise the benefits of control systems in a problem-oriented manner and develop solution strategies. In addition, the students can solve simple control engineering tasks, i.e. find the corresponding controllers and their parameterisation for simple technical processes. Students can resolve and simplify more complicated control engineering structures. In addition, the students can predict the behaviour of the closed control loop on the basis of a mathematical circuit model. In small groups, the students have gained initial experience with the design and implementation of simple controls for simple processes and have implemented and tested them using common simulation software such as MATLAB Simulink.

3 Contents:

Introduction to Control Engineering

- Terms
- Definitions
- Block diagrams

Transmission link analysis

- Steady-state and dynamic behaviour
- Frequency response and Bode diagram
- Determining mathematical models for technical systems
- The control loop
- Basic structure of the control loop
- Control loop structures
- Stability behaviour of control loops
- Classical linear controllers
- Simple design procedures
- Parameter-optimal controls

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	
Content:	

6 Forms of assessment:

	Term paper, written examination, project work or oral examination
7	Prerequisite for the award of credit points: Module examination pass and course assessment
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering and Management (work-integrated)B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: Prof. Dr.-Ing. Michael Leuer
11	Other information: -
12	Language: German

Safety and Security					SAS
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3259	150 h	5	6th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

The students are familiar with various guidelines in the field of functional safety. They are able to carry out a risk assessment and develop a technical safety concept. They have acquired knowledge about different validation concepts and can apply them. The students have an overview of the Machinery Directive as well as the standards IEC 61508 and EN ISO 13849 and have the understanding to apply these to real processes and technical systems.

They are familiar with the most important aspects of IT security and can create vulnerability, threat and risk analyses as well as security plans. They analyse operating system architectures with regard to the protection mechanisms integrated in them. They derive measures and mechanisms to increase reliability. They have a critical understanding of quantitative and provable security. The students can present and advocate their security solutions in an expert panel.

They have comprehensive basic knowledge of legal and data protection and the necessary technical and organisational measures to ensure the legally required data protection.

3 Contents:

Functional safety:

- IEC 61508, ISO 13849
- Machinery Directive and Declaration of Conformity
- Risk assessment, risk analysis, performance level
- Technical safety concept
- Validation concept and traceability

IT security/communication security:

- Basics of computer operating systems (especially internal protection mechanisms and related architectural features)
- Reliability and security objectives (confidentiality, integrity, availability, maintainability)
- Vulnerability, threat and risk analyses and security plan
- Measures and mechanisms to increase reliability and security of software and systems (cryptography, authentication, access control, protocols, firewalls, etc.)

	• Quantitative and provable security • Physical layer security • Methods against jamming Legal and data protection: • Legal basis • Technical-organisational measures to ensure the legally required data protection
4	Forms of teaching: Self-study units, exercises and practicals in the form of face-to-face events
5	Participation requirements: Formal: - Content: -
6	Forms of assessment: Term paper, written examination, project work or oral examination
7	Prerequisite for the award of credit points: Module examination pass and course assessment
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng. and Product-Service Engineering (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information: -
12	Language: German

Sensors and Actuators					SUA
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3350	150 h	5	5th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

The students explain the basics of measurement technology and error calculation. In the field of sensor technology, they know the transducer principles, properties, structure and design forms of sensors. They master description means and methods for sensor systems as an important step for the overall system design. Students acquire basic knowledge of signal processing and its application in the field of sensor technology. In addition, they gain insights into current fields of application of modern sensor technology.

In the field of actuators, students explain the basic technical and physical principles of mechanical, thermal and optical actuators. They know the areas of application of the different types of actuators and assess in a comparative manner which actuators in which application scenario should be used.

3 Contents:

Sensor technology:

- Fundamentals of measurement technology and error calculation
- Sensors: Definition of terms, categorisation according to transducer technologies, categorisation according to applications, sensor characterisation (accuracy, resolution, sensitivity, linearity) sensor signal chain: Signal processing and conditioning, design and realisation of analogue filters, analog-to-digital converter, digital-to-analog converter, sampling theorem sensor signal processing: Sensor error correction, discrete-time processing of analogue signals, spectral analysis/FFT, windowing, design and implementation of digital filters
- Construction of technical sensor systems: integration levels, aspects of embedded systems, connectivity/network connection

Actuator technology:

- Mechanical actuators: (electric) motors, hydraulics, pneumatics, valves , pumps, fans
- Thermal actuators: heating, cooling
- Optical actuators: luminaires, dimming, shading

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	

	Content:	• Mathematical basics • Module "Fundamentals of Physics/Electrical Engineering"
6	Forms of assessment: Written examination or oral examination	
7	Prerequisite for the award of credit points: Module examination pass	
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade: according to BRPO	
10	Module coordinator: N. N.	
11	Other information:	
12	Language: German	

Social Media and Natural Language Processing					SMNLP
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3351	150 h	5	5th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

- Students outline the history and business model of social media.
- They explain the technologies behind it.
- They create scripts to retrieve data from social media and for web crawling (e.g. to extract blog content or newspaper articles).
- They describe the fields of application of natural language processing and classify the techniques used there in the field of machine learning and data mining.
- They apply NLP methods for the syntactic and semantic analysis of text data.
- They implement toolchains in which data from social media is analysed using NLP methods in order to answer typical questions from marketing and sales or from social sciences.

3 Contents:

- Introduction to social media (history, business model, technologies)
- Retrieving data from social media (APIs)
- Retrieving data from websites and blogs (web crawling)
- Introduction to natural language processing (NLP) (history, motivation, fields of application, relation to other techniques of data mining and machine learning)
- NLP methods for the syntactic analysis of text data (e.g. for parsing or sentence breaking)
- NLP methods for the semantic analysis of text data (e.g. for sentiment analysis)
- Case studies from market research and from the social sciences

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	
Content:	• Mathematical basics • Basics of machine learning and data mining • Advanced programming skills

6 Forms of assessment:

	Written exam, project work or oral exam
7	Prerequisite for the award of credit points: Module examination pass
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information:
12	Language: German

Speech and Image Recognition					SUB
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3346	150 h	5	4th sem.	Annual (Summer)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	54	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

- The students explain the basics of deep learning (DL) and know the application area of DL.
- They explain the Fourier transform and apply it to speech and image data using ready-made software.
- They can implement and train DL networks using common toolboxes. Students select network topologies and training approaches appropriate to the learning problem at hand. The students know the basics of machine image processing and apply simple image processing operations to image data.
- They will train DL networks for object classification in images and for other image transformation tasks.
- They know the basics of machine speech processing and have an overview of speech recognition techniques.
- They will train DL networks for language recognition using simple examples.
- They assess the performance of the trained DL networks in comparison to other techniques of speech and image recognition.

3 Contents:

- Deep learning (DL): Foundations, optimisation methods, network topologies, training and application
- Fourier transform
- Introduction to machine vision
- Object classification in images using DL techniques
- Introduction to machine language processing
- Speech recognition in audio data using DL techniques

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5 Participation requirements:

Formal:	
Content:	• Mathematical basics and statistics • Advanced programming skills in Python

6 Forms of assessment:

Written exam, project work or oral exam

7 Prerequisite for the award of credit points:

Module examination pass and course assessment

8 Application of the module (in the following study programmes)

	Digital Technologies (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: N. N.
11	Other information:
12	Language: German

Statistics					STAT
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3224	150 h	5	3rd or 4th semester	each semester	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	2	SCH	16	h	62	h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students:

- can explain basic concepts of statistics.
- can apply the basic methods and procedures of descriptive statistics and probability theory.
- are able to analyse economic questions and problems with statistical methods and to show correlations.
- are able to solve tasks with the help of suitable software (SPSS, Excel,...).

3 Contents:

- Descriptive statistics (one-dimensional frequency distributions, measures, multivariate statistics, regression analysis)
- Probability theory (discrete and continuous distributions)
- Statistical interference
- Use of Excel/SPSS

4 Forms of teaching:

Learning units for self-study, classroom sessions in the form of exercises

5 Participation requirements:

Formal:	-
Content:	-

6 Forms of assessment:

Term paper, written examination, combined examination, project work, oral examination or examination accompanying the course

7 Prerequisite for the award of credit points:

Module examination pass

8 Application of the module (in the following study programmes)

Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics /Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering (work-integrated) B.Eng.

9 Importance of the grade for the final grade:

according to BRPO

10 Module coordinator:

Dr. rer. nat. Sabrina Proß

11 Other information:

-

12	Language: German

Technical English					TCE
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3121	150 h	5	1st, 3rd or 5th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	0	SCH	0	h	0	h
	Practical or seminar	15 students	2	SCH	32	h	46	h
	Supervised self-study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

- Expertise: The students acquire an extended active language competence at the upper B2 level. They have a sound specialist vocabulary of Technical English and can combine it with Business English terminology relevant to their profession.
- Social competence: they develop sensitivity to differences in intercultural communication, especially in English-speaking business environment.
- Methodological competence: They are able to skim specialist texts for essential information and present them shortly and concisely both in speaking and in writing. They establish wider contexts and make a critical assessment.
- Personal competence: They show English fluency and a pro-active approach to managing authentic English sources.

3 Contents:

- Students can actively participate in international conferences.
- They master engineering-relevant terminology (e.g. manufacturing processes; mathematical operations; dimensions and shapes; forces and mechanisms; properties of materials; automated systems and Industry 4.0).
- They possess interdisciplinary skills (e.g. discussing readings and trends; pitching a technical product; managing projects; designing conference posters; academic writing).

4 Forms of teaching:

Seminar-based teaching / individual and group work, etc. / semester project (Assignment)

5 Participation requirements:

Formal:	Regular attendance (70%) and active participation
Content:	English language competence: B1.2 (according to the European Reference Framework for Languages)

6 Forms of assessment:

	Combination examination
7	Prerequisite for the award of credit points: Passed semester project and written exam
8	Application of the module (in the following study programmes) Digital Logistics (work-integrated) B.Eng., Digital Technologies (work-integrated) B.Eng., Mechatronics/Automation (work-integrated) B.Eng., Product-Service Engineering (work-integrated) B.Eng. and Industrial Engineering and Management (work-integrated) B.Eng.
9	Importance of the grade for the final grade: according to BRPO
10	Module coordinator: OStR Cornelia Biegler-König
11	Other information: Literature will be announced at the beginning of the course. Textbook, additional materials, intranet self-study courses
12	Language: English

Networking and IoT Solutions					IOT
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3264	150 h	5	5th sem.	Annual (Winter)	1 semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	56	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self-study	60 students	1.5	SCH	24	h	0	h

2 Learning outcomes/competences:

Students can name and explain the different layers of the ISO-OSI communication model. They know the intersections between the individual layers and can apply them. They understand the essential processes between the individual communication layers and can name the data abstraction. Students have an overview of industrial fieldbuses, they know the common protocols and can interpret them. They understand the international standardisation of fieldbuses and are able to apply it. The students have basic knowledge in the area of the OPC-UA standard. They know the standardisation and specifications and can implement OPC clients and OPC servers. They simulate different bus systems with appropriate tools and analyse the data packets sent. They can evaluate different bus technologies and classify them for different applications. The students can illustrate the correlations between the bus technologies. They are familiar with the TCP/IP protocol and can use it for IoT solutions (Internet of Things). They know the essential principles of wireless communication and can name and describe their standards. They are able to apply their knowledge in the field of industrial communication and of wireless data transmission to IoT solutions.

3 Contents:

Introduction
Distributed Communication in Industrial Applications
The ISO-OSI Communication Model
Security layer: Access procedures, protocol security, reliability
Switching layer: Routing and device discovery, IP protocol
Transport layer: Providing quality of service
Session layer: Transaction security of unreliable channels
Presentation layer: Character representation and character encoding
Application layer: Application protocols and services

Industrial fieldbuses
International standardisation of fieldbuses
AS-Interface, CAN, Profibus, KNX, DeviceNet, ...
Ethernet-based real-time systems
EthernetIP, EtherCAT, ProfiNet, Powerlink,

IPC Global's standards
OPC-UA Standard

	Wireless Communication Basics Radio Technology Bluetooth, Wifi, IEEE802.15.4, WirelessHART, ... Coexistence of radio systems Peculiarities of the radio channel From point-to-point to multi-user systems From single-hop to multi-hop Wireless sensor networks Body-area networks Infrastructure as a service Spectrum Sharing Cloud Radio Access Networks Full duplex communication	
4	Forms of teaching:	
	Self-study units, exercises and practicals in the form of face-to-face events	
5	Participation requirements:	
	Formal:	-
	Content:	Module "Foundations of Computer Science"
6	Forms of assessment:	
	Term paper, written examination, project work or oral examination	
7	Prerequisite for the award of credit points:	
	Module examination pass and course assessment	
8	Application of the module (in the following study programmes)	
	Digital Technologies (work-integrated) B.Eng. and Product-Service Engineering (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	N. N.	
11	Other information:	
	-	
12	Language:	
	German	

Elective Module: Digital Technologies					WM
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
9006	150 h	5	5th or 6th semester	each semester	1 semester

	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
1	Lecture	60 students		SCH		h		h
	Tuition in seminars	30 students		SCH		h		h
	Exercise	20 students		SCH		h		h
	Practical or seminar	15 students	0	SCH	0	h	0	h
	Supervised self-study	60 students		SCH		h		h

2	Learning outcomes/competences:	
3	Contents:	
4	Forms of teaching:	
5	Participation requirements:	
	Formal:	
	Content:	
6	Forms of assessment:	
7	Prerequisite for the award of credit points:	
8	Application of the module (in the following study programmes) Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
10	Module coordinator: N. N.	
11	Other information:	
12	Language: German	

Web Technologies					WEB
Identification number:	Workload:	Credits:	Study semester:	Frequency of the offer	Duration:
3207	150	5	4th Semester	annually in the summer semester	1 Semester

1	Course:	Planned group sizes	Scope		Actual contact time / classroom teaching		Self-study	
	Lecture	60 students	2	SCH	0	h	64	h
	Tuition in seminars	30 students	0	SCH	0	h	0	h
	Exercise	20 students	1	SCH	8	h	46	h
	Practical or seminar	15 students	1	SCH	16	h	0	h
	Supervised self study	60 students	1	SCH	16	h	0	h

2 Learning outcomes/competences:

Students:

- implement simple web pages using appropriate tools; apply mark-up languages and common data exchange formats for web programming and data exchange;
- link databases to web interfaces;
- explain the basic concepts of the semantic web and place it in the canon of web technologies;
- explain the various technical, logical and legal influencing factors that play a role in e-business;
- discuss current and upcoming developments in the various areas and evaluate the effects on existing or planned E-business systems in the overall operational framework; explain the structure and the administration of E-business tools and comprehensive platform solutions.

3 Contents:

Internet technologies and architectures :

- Foundations of web programming
- Markup languages (e.g. XML) and data exchange formats (e.g. JSON)
- Integration of databases with web interfaces
- Fundamental concepts of the Semantic Web

E-business standards (data formats and rules for the exchange of information):

- Identification standards e.g. GTIN (Global Trade Item Number)
- Classification standards e.g. eCl@ss
- Catalogue exchange formats e.g. BMEcat
- Transaction standards e.g. EDIFACT, EDIFOR
- Process standards e.g. ECR (efficient consumer response)

Platform solutions:

- Cross-Channel Commerce Management Solutions
- E-commerce logistics fulfilment networks that enable national and international storage, handling and delivery of products (via an interface to online shop or ERP systems)

4 Forms of teaching:

Self-study units, exercises and practicals in the form of face-to-face events

5	Participation requirements:	
	Formal:	-
	Content:	• Good programming skills • Good knowledge of database technologies
6	Forms of assessment:	
	Term paper, written examination, project work or oral examination	
7	Prerequisite for the award of credit points:	
	Module examination pass and course assessment	
8	Application of the module (in the following study programmes)	
	Digital Logistics (work-integrated) B.Eng. and Digital Technologies (work-integrated) B.Eng.	
9	Importance of the grade for the final grade:	
	according to BRPO	
10	Module coordinator:	
	N. N.	
11	Other information:	
	-	
12	Language:	
	German	