Module-Handbook

M. Sc. Battery Systems Engineering

Table of Content

Compulsory Modules

Module: Modern Research Methods

Module	Modern Research Methods
Module ID	
Module level	Master
Subtitle	MoReMe
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	Univ.-Prof. Dr.-Ing. habil. Jaan-Willem Simon
Lecturer	Univ.-Prof. Dr.-Ing. habil. Jaan-Willem Simon
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded) or Oral Examination (Mündliche Prüfung, 100 %, graded)
Workload	Total 180 h, Lecture hours 45 h (4 SWS), Self-study 135 h
Lecture hours	4 SWS
ECTS-Credit Points (CP)	6
Learning objectives	After successfully completing this seminar, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding</u> Students know and understand • the relevance of working lege artis • the guidelines for Good Scientific Practice • foundations on research data management • the publication and review process • tools for literature review • tools for text editing in particular for scientific texts • strategies for verification and validation of models • foundations on statistics to evaluate modeling results • tools for plotting data • the structure of scientific papers and scientific presentations

	Abilities / Skills Students • work according the regulations for Good Scientific Practice • perform literature review • cite within scientific texts • verify and validate the obtained results • present the obtained results in appealing plots • write scientific texts with particular focus on the Master's thesis • give convincing presentations Competencies Students • conduct research according to Good Scientific Practice • evaluate scientific results in terms of verification, validation, and statistical soundness • present scientific results in written texts (papers, thesis, reports…) and in presentations
Content	This course provides students with guidelines for good scientific research. Concepts and methods are presented which are intended to help the students write their Master's thesis efficiently and systematically. Topics are: • the concept of „research" • planning and writing Master's/Doctoral theses or scientific articles Assembly procedure • presentation of research work in various forums • the use of tables and figures • proper citation, especially of electronic sources • ethical issues in research
Media	RWTHmoodle
Literature	Lecture Slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Modern Research Methods	6	0	0	See above
Lecture: Modern Research Methods	0	2	67,5	0
Exercise: Modern Research Methods	0	2	67,5	0

Teaching Unit / Examinations: Examination Modern Research Methods

Title	Examination Modern Research Methods

Sub-title	Exa MoReMe
Semester allocation	1
Connection to the curriculum	Compulsory Module
Teaching Unit / Examinations: Lecture Modern Research Methods	
Title	Lecture Modern Research Methods
Sub-title	L MoReMe
Semester allocation	1
Connection to the curriculum	Compulsory Module
Teaching Unit / Examinations: Exercise Modern Research Methods	
Title	Exercise Modern Research Methods
Sub-title	E MoReMe
Semester allocation	1
Connection to the curriculum	Compulsory Module

Module: Fundamentals of Lithium-Ion-Batteries and Battery Systems

Module	Fundamentals of Lithium-Ion-Batteries and Battery Systems
Module ID	
Module level	Master
Subtitle	FLIBS
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • Elaborate the fundamentals of Electrochemistry • Elaborate the fundamentals of of batteries and different cell chemistries • Interpret different state variables • Distinguish the difference between different chemistries • Categorize the different battery components and their roles • Conceptualize electrical battery testing and battery system design • Understand fundamentals of battery aging processes • Explain various safety feature in battery design processes
Content	Topic 1: “Fundamentals of electrochemistry and electrical engineering for battery systems” • Fundamental electrochemical laws and equations (e.g., Butler-Volmer, Nernst, etc.) • Fundamentals of electrical networks and laws in connection with battery systems • Function principle of electrochemical energy storage

	• Terminology of different state variables (e.g. SOC, SOP, SOH etc.) • Overview and comparison of different electrochemical energy storage technologies Topic 2: “Lithium-Ion Battery” • Classification and working principle of lithium-ion-batteries • Different used chemistries and their properties • Design and components of lithium-ion batteries • Short overview of dominant ageing processes • Safety properties • Design of experiments for electrical testing
Media	RWTHmoodle
Literature	Lecture Slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Fundamentals of Lithium-Ion-Batteries and Battery Systems	5	0	0	See above
Lecture: Fundamentals of Lithium-Ion-Batteries and Battery Systems	0	2	77	0
Fundamentals of Lithium-Ion-Batteries and Battery Systems	0	1	39	0

Teaching Unit / Examinations: Examination Fundamentals of Lithium-Ion-Batteries and Battery Systems

Title	Examination Fundamentals of Lithium-Ion-Batteries and Battery Systems
Sub-title	Exa FLIBS
Semester allocation	1
Connection to the curriculum	Compulsory Module

Teaching Unit / Examinations: Lecture Fundamentals of Lithium-Ion-Batteries and Battery Systems

Title	Lecture Fundamentals of Lithium-Ion-Batteries and Battery Systems
Sub-title	L FLIBS
Semester allocation	1
Connection to the curriculum	Compulsory Module

Teaching Unit / Examinations: Exercise Fundamentals of Lithium-Ion-Batteries and Battery Systems	
Title	Exercise Fundamentals of Lithium-Ion-Batteries and Battery Systems
Sub-title	E FLIBS
Semester allocation	1
Connection to the curriculum	Compulsory Module

Module: Energy Storage Systems - Future Technologies and Innovations

Module	Energy Storage Systems - Future Technologies and Innovations
Module ID	
Module level	Master
Subtitle	ESS-FTI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Prof. Dr. rer. nat. Egbert Figgemeier
Lecturer	Prof. Dr.-Ing. Stefan Pischinger , Prof. Dr. rer. nat. Egbert Figgemeier
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Lecture, Exercise
Examination mode	Written examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • Assess hydrogen technologies • Understand the hydrogen economy and infrastructure • Evaluating and comparing different energy storage technologies • Evaluate the potential of alternative battery technologies • Assess disruptive and sustainable innovations • Creating strategies for dealing with disruptive battery development
Content	Topic 1: “Hydrogen Technologies and Hydrogen Economy & Potential of Alternative Battery Technologies” • Hydrogen production / electrolyser • Hydrogen economy and infrastructure • Fuel cells • Derivatives such as ammonia, methane, methanol, eFuels, etc. • Biofuels • Commercial non-lithium battery systems and SuperCaps • Redox flow batteries (vanadium, organic active materials (biogenic, or oil-based), semi-flow)

<table>
<tr><td></td><td colspan="4">• Innovative battery technology design, such as Sodium-ion batteries, Solid-state batteries, Li-sulphur
<u>Topic 2: “Disruptive Battery Technologies and Innovation”</u>
• Adjusting the Performance of the Lithium-Ion Cell to the Application through Balancing the Chemistry
• Impact of Battery Aging on the Business Case
• Product and Innovation Cycles in the Battery Industry
• Disruptive and Sustainable Innovations
• Strategies for Start-Ups and Companies in Dealing with Disruptive Battery Development</td></tr>
<tr><td>Media</td><td colspan="4">RWTHmoodle</td></tr>
<tr><td>Literature</td><td colspan="4">Lecture slides</td></tr>
<tr><td colspan="5">Lectures / Examinations</td></tr>
<tr><td rowspan="2">Title</td><td rowspan="2">ECTS</td><td colspan="2">Workload</td><td rowspan="2">Duration of Exam (min)</td></tr>
<tr><td>Lecture h. (SWS)</td><td>Self-Study (h)</td></tr>
<tr><td>Examination: Energy Storage Systems - Future Technologies and Innovations</td><td>5</td><td>0</td><td>0</td><td>See above</td></tr>
<tr><td>Lecture: Energy Storage Systems - Future Technologies and Innovations</td><td>0</td><td>2</td><td>77</td><td>0</td></tr>
<tr><td>Exercise: Energy Storage Systems - Future Technologies and Innovations</td><td>0</td><td>1</td><td>39</td><td>0</td></tr>
<tr><td colspan="5">Teaching Unit / Examinations: Examination Energy Storage Systems - Future Technologies and Innovations</td></tr>
<tr><td>Title</td><td colspan="4">Examination Energy Storage Systems - Future Technologies and Innovations</td></tr>
<tr><td>Sub-title</td><td colspan="4">Exa ESS-FTI</td></tr>
<tr><td>Semester allocation</td><td colspan="4">2</td></tr>
<tr><td>Connection to the curriculum</td><td colspan="4">Compulsory Module</td></tr>
<tr><td colspan="5">Teaching Unit / Examinations: Lecture Energy Storage Systems - Future Technologies and Innovations</td></tr>
<tr><td>Title</td><td colspan="4">Lecture Energy Storage Systems - Future Technologies and Innovations</td></tr>
</table>

Sub-title	L ESS-FTI
Semester allocation	2
Connection to the curriculum	Compulsory Module
Teaching Unit / Examinations: Exercise Energy Storage Systems - Future Technologies and Innovations	
Title	Exercise Energy Storage Systems - Future Technologies and Innovations
Sub-title	E ESS-FTI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Fundamentals of Battery System Design

Module	Fundamentals of Battery System Design
Module ID	
Module level	Master
Subtitle	FBSD
Lecture	See list of lectures and examinations of the module
Semester allocation	3
Person in charge	Prof. Dr.-Ing. Peter Urban
Lecturer	Dr.-Ing. Hartung Wilstermann, Prof. Dr.-Ing. Peter Urban
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • Understand industrial development processes • Analyze the requirements for the product conception and the performance parameters • Generate product and component requirements document • Analyze the production steps • Assess the planning of a factory, the procurement system, and emergency planning and occupational safety • Explain the ramping-up and optimization of a production line • Illustrate quality and supplier management • Classify in-line battery testing and product quality assurance • Apply the fundamentals of thermodynamics to batteries • Distinguish the differences of the different cooling systems • Categorize the temperature distribution within battery cells • Design a suitable cooling system for a battery system depending on the requirements

<table>
<tr><td>Content</td><td colspan="4">Topic 1: “Industrial product development process using the example of Battery systems for hybrid and electric vehicles”
Overview of the industrial development process with a focus on the automotive sector
Product conception: requirements, overall concept, performance parameters (KPI), product requirements document (PRD), etc.
Product development: product development process, monitoring of battery cells, component requirements document, testing of battery cells, regulations and patent system
Production planning and controlling: design-to-cost, procurement system, production steps, factory planning, facility requirements, emergency planning, occupational safety, etc.
Start of series production: Quality assurance, test benches, ramping up and optimization of a production line, etc.
Product management: Quality and supplier management, failure analysis in the field, field experiences, etc.
Topic 2: “Thermal Management of Batteries and Cooling Techniques”
Recap the fundamentals of thermodynamics
Overview of different cooling concepts for battery systems
Temperature distribution within battery cells and packs
Thermal models of batteries
Materials of cooling systems
Comparison of different approaches</td></tr>
<tr><td>Media</td><td colspan="4">RWTHmoodle</td></tr>
<tr><td>Literature</td><td colspan="4">Lecture slides</td></tr>
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<tr><td>Lecture h. (SWS)</td><td>Self-Study (h)</td></tr>
<tr><td>Examination: Fundamentals of Battery System Design</td><td>5</td><td>0</td><td>0</td><td>See above</td></tr>
<tr><td>Lecture: Fundamentals of Battery System Design</td><td>0</td><td>2</td><td>77</td><td>0</td></tr>
<tr><td>Exercise: Fundamentals of Battery System Design</td><td>0</td><td>1</td><td>39</td><td>0</td></tr>
<tr><td colspan="5">Teaching Unit / Examinations: Examination Fundamentals of Battery System Design</td></tr>
<tr><td>Title</td><td colspan="4">Examination Fundamentals of Battery System Design</td></tr>
<tr><td>Sub-title</td><td colspan="4">Exa FBSD</td></tr>
<tr><td>Semester allocation</td><td colspan="4">3</td></tr>
<tr><td>Connection to the curriculum</td><td colspan="4">Compulsory Module</td></tr>
</table>

Teaching Unit / Examinations: Lecture Fundamentals of Battery System Design	
Title	Lecture Fundamentals of Battery System Design
Sub-title	L FBSD
Semester allocation	3
Connection to the curriculum	Compulsory Module
Teaching Unit / Examinations: Exercise Fundamentals of Battery System Design	
Title	Exercise Fundamentals of Battery System Design
Sub-title	E FBSD
Semester allocation	3
Connection to the curriculum	Compulsory Module

Seminarprojects (Compulsory Modules)

Module: Production, Testing, Recycling, and Circular Economy of Battery and Energy Storage Systems

Module	Production, Testing, Recycling, and Circular Economy of Battery and Energy Storage Systems
Module-ID	
Module level	Master
Subtitle	SP1
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	• Passing the exams of the modules: o Fundamentals of Chemistry and Engineering for Batteries and o Fundamentals of Thermodynamics and Data Processing for Batteries
Teaching form	Student-led presentations and peer discussions during seminar sessions, hands-on experiments in the laboratory Attendance is mandatory.
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min. each) - presentation and colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 150 h, Lab hours: 50 h, Seminar hours: 30 h, Self-study: 70 h
ECTS-Credit Points (CP)	5
Learning Objectives	After successful participation in the module course, students are able to: • Develop their own battery ageing experiments • Understand the fundamental approach to battery degradation testing • Explain issues related to battery production or deployment in large-scale storage systems

Content	This module combines a Seminar on battery technologies, production, and circular economy with respect to batteries with hands-on experiments to evaluate currently available batteries, which provide the possibility to apply and complement theoretically acquired knowledge from the study program into a practical workplace setting. Students should deepen their specialized interdisciplinary knowledge in development, usage and recycling of batteries, while also keeping a wider perspective on issues related to battery production and applications.
Media	RWTHmoodle
Literature	Lecture slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Production, Testing, Recycling, and Circular Economy of Battery and Energy Storage Systems	5	0	0	See above
Seminarproject: Production, Testing, Recycling, and Circular Economy of Battery and Energy Storage Systems	0	5	70	0

Teaching Unit / Examinations: Examination Production, Testing, Recycling and Circular Economy of Battery and Energy Storage Systems

Title	Examination Production, Testing, Recycling and Circular Economy of Battery and Energy Storage Systems
Sub-title	Exa SP1
Semester allocation	2
Connection to the curriculum	Compulsory Module

Teaching Unit / Examinations: Seminarproject Production, Testing, Recycling and Circular Economy of Battery and Energy Storage Systems

Title	Seminarproject Production, Testing, Recycling and Circular Economy of Battery and Energy Storage Systems
Sub-title	S SP1
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Batteries in Future Energy Systems

Module	Batteries in Future Energy Systems
Module-ID	
Module level	Master
Subtitle	SP2
Lecture	See list of lectures and examinations of the module
Semester allocation	3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	Production, Testing, Recycling and Circular Economy of Battery and Energy Storage Systems
Teaching form	Student-led presentations and peer discussions during seminar sessions, hands-on experiments in the laboratory Attendance is mandatory.
Examination mode	The final examination is composed as follows: - presentation (Referat, 50%, not graded, 15 min. each) - presentation and colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 150 h, Lab hours: 50 h, Seminar hours: 30 h, Self-study: 70 h
ECTS-Credit Points (CP)	5 CP
Learning Objectives	After successful participation in the module course, students are able to: • Analyze battery testing results • Apply battery testing results to design batteries across various applications • Assess the role of batteries in future energy systems • Understand the societal impacts of on battery applications
Content	This module combines a seminar on the role of batteries in future energy systems including issues like climate change, regulations and energy markets with hands-on experiments on battery performance and ageing.

	This helps to translate results of scientific experiments to applications. It also widens students' horizons and invites them to include non-technical aspects in their investigations and decisions.			
Media	RWTHmoodle			
Literature	Lecture Slides			
Lectures / Examinations				
Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Batteries in Future Energy Systems	5	0	0	See above
Seminarproject: Batteries in Future Energy Systems	0	5	70	-
Teaching Unit / Examinations: Examination Batteries in Future Energy Systems				
Title	Examination Batteries in Future Energy Systems			
Sub-title	Exa SP2			
Semester allocation	3			
Connection to the curriculum	Compulsory Module			
Teaching Unit / Examinations: Seminarproject Batteries in Future Energy Systems				
Title	Seminarproject Batteries in Future Energy Systems			
Sub-title	S SP2			
Semester allocation	3			
Connection to the curriculum	Compulsory Module			

Research Internship (Compulsory Module)

Module: Research Internship

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	The students learn and work directly on current scientific issues in cooperation with the scientific staff of industrial companies. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.
Content	Varied and diverse topics that are connected to the various aspects of battery life cycle. The research lab should provide the possibility to apply and complement theoretically acquired knowledge from the study program in a practical workplace setting. Students should deepen their specialized interdisciplinary knowledge in battery development, usage, and recycling.

Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2

Module: Chemical and Physical Cell and Material Analysis

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Apply chemical and physical methods to evaluate battery cells and materials • Scrutinize the results obtained from chemical and physical methods • Perform experiments independently in a lab environment
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students get familiar with new topics with the help of scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, use of equipment, and documentation. Students carry out electrical measurements on batteries, electronics and sensor technology, physical and chemical analyses on battery cells, or solid and liquid materials related to batteries. Students develop, implement, and validate measurement procedures, as well as software tools to analyze the data as required. The research lab should allow students to apply and complement theoretically acquired knowledge from the study program in a practical workplace setting. Students should deepen their specialized interdisciplinary knowledge in battery development, usage, and recycling.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Diagnostics

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals of battery state estimation algorithms • Assess the battery algorithm performance across various application scenarios • Understand different requirements for algorithm design
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in

	various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models. Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students apply different diagnostic algorithms for state estimation. They develop various diagnostic algorithms based on their understanding of the fundamental electrical, physical, or chemical properties and their description in the scientific literature. The students are able to validate the functionality of their algorithms.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Modelling

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals of battery models and their application • Understand the fundamentals of parameter fitting and algorithms • Apply validation techniques to analyze the performance of battery model parameterizations
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students apply and parameterize battery models of different complexity, such as equivalent circuit models or electrochemical models. They apply various fitting algorithms based on the understanding of the fundamental electrical, physical, or chemical properties and the description in the scientific literature.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Recycling and Life Cycle Analysis

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals, challenges, and chances of battery system recycling • Assess and compare different deassembling and recycling processes • Apply methods for life cycle analysis
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students analyze existing recycling processes. They apply those processes to different battery system designs and conduct quality assurance procedures in the laboratory.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Production

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Understand different production steps for different cell chemistries • Analyze techniques for quality assessment • Understand the challenges and chances in battery cell production
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models. The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs or also at industrial companies or partner chairs abroad. In the process, students gain

	deep insight and the ability to work independently in various subject areas. This also includes familiarization with different laboratory equipment or, for example, simulation or diagnostic models. Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students analyze existing production processes and their implementation. They analyze production steps and understand material and energy efficiency, product cycle times, and quality assurance procedures.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Battery Pack Design and Battery Management System (HW)

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Understand the battery system design process (mechanical, electrical, thermal) • Understand the fundamentals of sensor design and communication for battery management systems • Analyze different battery management system topologies#
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students familiarize themselves with comprehensive software packages, such as those for battery modelling or battery diagnostics, as well as the design, implementation, verification, and integration of software modules into software packages and documentation. Students plan, construct, and verify battery module and pack design, including the integration of thermal and electrical management systems and monitoring units.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Sensors, Measurement Devices and Electronics

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals of sensor techniques and their application during development and production processes • Assess and compare innovative sensor techniques, such as ultrasound, CT, EIS# • Analyze real measurement and imaging data##
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students develop a deep understanding of the measurement principles of different devices in the laboratory or in field facilities. They operate, maintain, monitor, and analyze data from laboratory and field test facilities.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Module: Laboratory or Field Installation or Operation of Mobile or Stationary Battery Systems

Module	Research Internship
Module-ID	
Module level	Master
Subtitle	RI
Lecture	See list of lectures and examinations of the module
Semester allocation	2
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)#
Workload	Total: 300 h, minimum 14 weeks
ECTS-Credit Points (CP)	10
Learning Objectives	After successful participation in the module course, students are able to: • Understand different applications for electrification# • Analyze field data from vehicles or stationary storage systems#
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models. Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the

	respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students develop a deep understanding of the measurement principles of different devices in the laboratory or in field facilities. They operate, maintain, monitor, and analyze data from laboratory and field test facilities.
Teaching Unit / Examinations: Examination Research Internship	
Title	Examination Research Internship
Sub-title	Exa RI
Semester allocation	2
Connection to the curriculum	Compulsory Module

Research Labs (Elective Modules)

Module: Chemical and Physical Cell and Material Analysis

Module	Chemical and Physical Cell and Material Analysis
Module-ID	
Module level	Master
Subtitle	RLCMA
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission in the course Physical and Chemical Methods for Post-Mortem Investigations of Batteries
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Apply chemical and physical methods to evaluate battery cells and materials • Scrutinize the results obtained from chemical and physical methods • Perform experiments independently in a lab environment
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in

	various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models. Students get familiar with new topics with the help of scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, use of equipment, and documentation. Students carry out electrical measurements on batteries, electronics and sensor technology, physical and chemical analyses on battery cells, or solid and liquid materials related to batteries. Students develop, implement, and validate measurement procedures, as well as software tools to analyze the data as required. The research lab should allow students to apply and complement theoretically acquired knowledge from the study program in a practical workplace setting. Students should deepen their specialized interdisciplinary knowledge in battery development, usage, and recycling.
Teaching Unit / Examinations: Examination Chemical and Physical Cell and Material Analysis	
Title	Examination Chemical and Physical Cell and Material Analysis
Sub-title	Exa RLCMA
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Diagnostics

Module	Diagnostics
Module-ID	
Module level	Master
Subtitle	RLD
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission in the course Advanced Battery Diagnostics and Machine Learning
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50%, not graded, 15 min.)
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals of battery state estimation algorithms • Assess the battery algorithm performance across various application scenarios • Understand different requirements for algorithm design
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students apply different diagnostic algorithms for state estimation. They develop various diagnostic algorithms based on their understanding of the fundamental electrical, physical, or chemical properties and their description in the scientific literature. The students are able to validate the functionality of their algorithms.
Teaching Unit / Examinations: Examination Diagnostics	
Title	Examination Diagnostics
Sub-title	Exa RLD
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Modelling

Module	Modelling
Module-ID	
Module level	Master
Subtitle	RLM
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission in the course Battery Modeling and Mobile Applications
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals of battery models and their application • Understand the fundamentals of parameter fitting and algorithms • Apply validation techniques to analyze the performance of battery model parameterizations
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students apply and parameterize battery models of different complexity, such as equivalent circuit models or electrochemical models. They apply various fitting algorithms based on the understanding of the fundamental electrical, physical, or chemical properties and the description in the scientific literature.
Teaching Unit / Examinations: Examination Modelling	
Title	Examination Modelling
Sub-title	Exa RLM
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Recycling and Life Cycle Analysis

Module	Recycling and Life Cycle Analysis
Module-ID	
Module level	Master
Subtitle	RLRLCA
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission in the course Economics of Battery Applications and Recycling
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals, challenges, and chances of battery system recycling • Assess and compare different deassembling and recycling processes • Apply methods for life cycle analysis#
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students analyze existing recycling processes. They apply those processes to different battery system designs and conduct quality assurance procedures in the laboratory.
Teaching Unit / Examinations: Examination Recycling and Life Cycle Analysis	
Title	Examination Recycling and Life Cycle Analysis
Sub-title	Exa RLRLCA
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Production

Module	Production
Module-ID	
Module level	Master
Subtitle	RLP
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission in the course Advanced Battery Production Technology
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min. each) - colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Understand different production steps for different cell chemistries • Analyze techniques for quality assessment • Understand the challenges and chances in battery cell production
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models. The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs or also at

	industrial companies or partner chairs abroad. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different laboratory equipment or, for example, simulation or diagnostic models. Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students analyze existing production processes and their implementation. They analyze production steps and understand material and energy efficiency, product cycle times, and quality assurance procedures.
Teaching Unit / Examinations: Examination Production	
Title	Examination Production
Sub-title	Exa RLP
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Battery Pack Design and Battery Management System (HW)

Module	Battery Pack Design and Battery Management System (HW)
Module-ID	
Module level	Master
Subtitle	RLBPDMS
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission in the course Hardware of Battery Packs & Stationary Applications
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50%, not graded, 15 min.) - colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Understand the battery system design process (mechanical, electrical, thermal) • Understand the fundamentals of sensor design and communication for battery management systems • Analyze different battery management system topologies#
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students familiarize themselves with comprehensive software packages, such as those for battery modelling or battery diagnostics, as well as the design, implementation, verification, and integration of software modules into software packages and documentation. Students plan, construct, and verify battery module and pack design, including the integration of thermal and electrical management systems and monitoring units.
Teaching Unit / Examinations: Examination Battery Pack Design and Battery Management System (HW)	
Title	Examination Battery Pack Design and Battery Management System (HW)
Sub-title	Exa RLBPDMS
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Sensors, Measurement Devices and Electronics

Module	Sensors, Measurement Devices and Electronics
Module-ID	
Module level	Master
Subtitle	RLSMDE
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission in the course Advanced Battery Diagnostics and Machine Learning
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %, not graded, 15 min. each) - colloquium (Kolloquium, 50 %, not graded, 15 min.)
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Understand the fundamentals of sensor techniques and their application during development and production processes • Assess and compare innovative sensor techniques, such as ultrasound, CT, EIS# • Analyze real measurement and imaging data#
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students carry out electrical measurements on batteries, electronics and sensor technology or physical and chemical analyses on battery cells and solid and liquid materials.
Teaching Unit / Examinations: Examination Sensors, Measurement Devices and Electronics	
Title	Examination Sensors, Measurement Devices and Electronics
Sub-title	Exa RLSMDE
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Laboratory or Field Installation or Operation of Mobile or Stationary Battery Systems

Module	Laboratory or Field Installation or Operation of Mobile or Stationary Battery Systems
Module-ID	
Module level	Master
Subtitle	RLLFIO
Lecture	See list of lectures and examinations of the module
Semester allocation	1 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	-
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	Exam admission to the course Economics of Battery Applications and Recycling
Teaching form	Internship
Examination mode	The final examination is composed as follows: - presentation (Referat, 50 %,not graded, 15 min. each) - colloquium (Kolloquium, 50%, not graded, 15 min.)#
Workload	Total: 300 h, Lab-hours: 290 h, Self-study: 10 h, min. 14 weeks with occupation of 75%
ECTS-Credit Points (CP)	10 CP
Learning Objectives	After successful participation in the module course, students are able to: • Understand different applications for electrification# • Analyze field data from vehicles or stationary storage systems#
Content	The students learn and work directly on current scientific issues in cooperation with the scientific staff of the participating chairs. In the process, students gain deep insight and the ability to work independently in various subject areas. This also includes familiarization with different equipment in laboratories or, for example, simulation or diagnostic models.

	Students familiarize themselves with new topics through scientific literature, technical documentation, and documented preliminary work in the respective working group. They systematically plan scientific work, including time schedules, resource planning, equipment use, and documentation. Students develop a deep understanding of the measurement principles of different devices in the laboratory or in field facilities. They operate, maintain, monitor, and analyze data from laboratory and field test facilities.
Teaching Unit / Examinations: Examination Laboratory or Field Installation or Operation of Mobile or Stationary Battery Systems	
Title	Examination Laboratory or Field Installation or Operation of Mobile or Stationary Battery Systems
Sub-title	Exa RLLFIO
Semester allocation	1 or 3
Connection to the curriculum	Compulsory Elective Module

Elective Modules

Module: Physical and Chemical Methods for Post-Mortem Investigations of Batteries

Module	Physical and Chemical Methods for Post-Mortem Investigations of Batteries
Module ID	
Module level	Master
Subtitle	PCM-PMI
Lecture	See list of lectures and examinations of the module
Semester allocation	1, 2 or 3
Person in charge	Prof. Dr. rer. nat. Mayer
Lecturer	Dr. rer. nat. Finsterbusch, Prof. Dr. rer. nat. Mayer
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	To be admitted to the exam, passing a test (module component) is required.
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • Transfer fundamentals of imaging technologies • Classify imaging technologies for analytical battery research • Combine results of destructive analytical methods such as ICP-OES and GC-MS and results of non-destructive methods such as EIS, GITT, DVA, ICA, and Pulse Resistance measurements • Understand the fundamentals of innovative methods currently under development
Content	• Fundamentals of Imaging Technologies (CT, Microscopy, Laser-Microscopy, Scanning Electron Microscopy, EDX) • Applications of analytical chemistry for battery research • Methods: ICP-OES, GC-MS, coating thickness determination • Physical Analytics in Battery Research

	○ EIS, GITT, (q)OCV (incl. DVA, ICA), Pulse resistance • Innovative methods for battery research (µ-calorimetry, float currents, methods currently under development)
Media	RWTHmoodle
Literature	Lecture Slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Physical and Chemical Methods for Post-Mortem Investigations of Batteries	5	0	0	See above
Lecture: Physical and Chemical Methods for Post-Mortem Investigations of Batteries	0	2	77	0
Exercise: Physical and Chemical Methods for Post-Mortem Investigations of Batteries	0	1	39	0

Teaching Unit / Examinations: Examination Physical and Chemical Methods for Post-Mortem Investigations of Batteries

Title	Examination Physical and Chemical Methods for Post-Mortem Investigations of Batteries
Sub-title	Exa PCM-PMI
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Teaching Unit / Examinations: Lecture Physical and Chemical Methods for Post-Mortem Investigations of Batteries

Title	Lecture Physical and Chemical Methods for Post-Mortem Investigations of Batteries
Sub-title	L PCM-PMI
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Teaching Unit / Examinations: Exercise Physical and Chemical Methods for Post-Mortem Investigations of Batteries	
Title	Exercise Physical and Chemical Methods for Post-Mortem Investigations of Batteries
Sub-title	E PCM-PMI
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Battery Modeling and Machine Learning

Module	Battery Modeling and Machine Learning
Module ID	
Module level	Master
Subtitle	BaMa
Lecture	See list of lectures and examinations of the module
Semester allocation	1, 2 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer
Lecturer	Univ.-Prof. Dr. rer. nat. Dirk Uwe Sauer, Dr. -Ing. Weihan Li
Language	English
Assignment to the curriculum	Elective Module
Recommended requirements	None
Participation requirements (study program specific)	To be admitted to the exam, passing a test (module component) is required.
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • develop electrical models for batteries • generate measurement data for the parametrization of electrical models • analyze different thermal battery models • assess thermal propagation within a battery cell and module • assess the structure and parametrization of different ageing models • categorize mechanical models for cells and modules • understand the fundamentals of AI & Machine Learning • evaluate the parameterization of models • evaluate the lifetime prediction and diagnostics of battery with AI & Machine Learning • assess different AI and ML algorithm and model
Content	<u>Topic 1: “Battery Modeling – from Crystal to System”</u> • Electrical modeling of batteries: equivalent circuit models, physical-chemical models

	• Parametrization of electrical models • Validation of electrical models • Thermal battery models: structure, parametrization, validation • Ageing models: structure, parametrization, validation • Design of experiment for model parametrization# Topic 2: “Artificial Intelligence and Machine Learning for Battery Technologies” • Basics of AI and ML • Applications in online diagnostics • Model parameterization • Lifetime prediction • Modelling • Basics of AI and ML (Advantages: Problems: Overfitting ...) • Applications: Modelling: black-box AI, grey-box AI, physically informed AI models • Diagnostics, service life prediction, energy management, AI in the production process (quality prediction), AI in system design • system design#
Media	RWTHmoodle
Literature	Lecture slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Battery Modeling and Mobile Applications	5	0	0	See above
Lecture: Battery Modeling and Mobile Applications	0	2	77	0
Exercise: Battery Modeling and Mobile Applications	0	1	39	0

Teaching Unit / Examinations: Examination Battery Modeling and Machine Learning

Title	Examination Battery Modeling and Machine Learning
Sub-title	Exa BaMa
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Teaching Unit / Examinations: Lecture Battery Modeling and Machine Learning

Title	Examination Battery Modeling and Machine Learning
Sub-title	L BaMa

Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Exercise Battery Modeling and Machine Learning	
Title	Examination Battery Modeling and Machine Learning
Sub-title	E BaMa
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Advanced Battery Diagnostics and Mobile Applications

Module	Advanced Battery Diagnostics and Mobile Applications
Module ID	
Module level	Master
Subtitle	ABDMA
Lecture	See list of lectures and examinations of the module
Semester allocation	1, 2 or 3
Person in charge	Dr. -Ing. Florian Ringbeck
Lecturer	Dr. -Ing. Florian Ringbeck
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	To be admitted to the exam, passing a test (module component) is required.
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • understand different battery state variables • derive critical system conditions • evaluate different diagnostic algorithm and their advantages and disadvantages for the application and diagnostic factor • analyze the hardware of battery management systems • assess advanced BMS algorithm and hardware • distinguish the requirements of different mobile applications on the battery system • analyze the Life Cycle Analysis of battery systems • categorize the requirements for the charging system • derive the need and requirements for energy management systems and the optimization of those
Content	Topic 1: “Battery Diagnostics” • Fundamentals of battery diagnostics • Critical system conditions

	• Different diagnostic factors, like SOC, SOP, SOE, SOH, etc. • Classic diagnostic algorithm, like coulomb counting • Advanced diagnostic algorithm • Evaluation of diagnostic algorithm • Limitations of the battery management system (BMS) • Sensors of the BMS and system architecture Advanced on-board sensors (Ultrasounds, EIS, optic fiber, etc.) Topic 2: "Battery Systems in Mobile Applications incl. Life Cycle Analysis, Load and Requirement Profiles" • Mobile Applications: Cars, commercial vehicles, trucks, cruise ships, ferries, aviation, agricultural machinery, construction machinery etc. • Analysis of different load profiles and requirements for the battery system • Life cycle analysis of a battery-electric application • Different requirements for the charging system • Energy management system • Operational optimization • Mechanical properties of the cell and module, such as swelling/aging due to mechanical stress • Thermal properties of cell and module • Thermal propagation / venting gas simulation/arcing (arcing)
Media	RWTHmoodle
Literature	Lecture Slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Advanced Battery Diagnostics and Mobile Applications	5	0	0	See above
Lecture: Advanced Battery Diagnostics and Mobile Applications	0	2	77	0
Exercise: Advanced Battery Diagnostics and Mobile Applications	0	1	39	0

Teaching Unit / Examinations: Examination Advanced Battery Diagnostics and Mobile Applications

Title	Examination Advanced Battery Diagnostics and Mobile Applications
Sub-title	Exa ABDMA
Semester allocation	1, 2 or 3

Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Lecture Advanced Battery Diagnostics and Mobile Applications	
Title	Lecture Advanced Battery Diagnostics and Mobile Applications
Sub-title	L ABDMA
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Exercise Advanced Battery Diagnostics and Mobile Applications	
Title	Exercise Advanced Battery Diagnostics and Mobile Applications
Sub-title	E ABDMA
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Advanced Battery Production Technology

Module	Advanced Battery Production Technology
Module ID	
Module level	Master
Subtitle	ABPT
Lecture	See list of lectures and examinations of the module
Semester allocation	1, 2 or 3
Person in charge	Prof. Dr.-Ing. Achim Kampker
Lecturer	Prof. Dr.-Ing. Achim Kampker, Prof. Dr.-Ing. Dipl. -Wirt. -Ing. Heiner Heimes
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	To be admitted to the exam, passing a test (module component) is required.
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • analyze battery production processes • discuss supply chain issues related to battery production • assess safety issues in lithium-ion batteries • evaluate the advantages and disadvantages of new production processes • identify suitable end-of-line quality test procedures
Content	Topic 1: Battery Cell Production Technology • Production steps (incl. work at upstream suppliers along the value chain) • Production facilities • Quality assurance • Energy requirements, sustainability & costs • Optimization conflicts • New processes (dry coating, pre lithiation...)

	• Quality assurance on the production line • End-of-line quality tests (possibly with input from ISEA regarding ultrasound, float current measurements, EIS) Topic 2: Battery Production – Logistics and Factory Planning • Supply chains from raw material to battery production • Regulations for transportation and handling of battery cells (UN 38.3) • Dangers posed by batteries during transportation • Time-critical processes (e.g. filling + application of the wetting voltage) • Factory planning (clean room, drying room, space requirements, safety requirements)
Media	RWTHmoodle
Literature	Lecture Slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Advanced Battery Production Technology	5	0	0	See above
Lecture: Advanced Battery Production Technology	0	2	77	0
Exercise: Advanced Battery Production Technology	0	1	39	0

Teaching Unit / Examinations: Examination Advanced Battery Production Technology	
Title	Examination Advanced Battery Production Technology
Sub-title	Exa ABPT
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Lecture Advanced Battery Production Technology	
Title	Lecture Advanced Battery Production Technology
Sub-title	L ABPT
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Exercise Advanced Battery Production Technology	

Title	Exercise Advanced Battery Production Technology
Sub-title	E ABPT
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Economics of Battery Applications and Recycling

Module	Economics of Battery Applications and Recycling
Module ID	
Module level	Master
Subtitle	EBAR
Lecture	See list of lectures and examinations of the module
Semester allocation	1, 2 or 3
Person in charge	Prof. Dr.-Ing. Dr. h.c.Bernhard Friedrich
Lecturer	Prof. Dr.-Ing. Dr. h.c.Bernhard Friedrich, Prof. Dr. rer. nat. Dirk Uwe Sauer
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	None
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • examine geopolitical dependencies with respect to material availability • understand the sustainability and criticality of raw materials • evaluate the challenges of recycling processes and second life applications from both a technology as well as a business perspective • understand charging stations and standards • develop business models for charging stations
Content	Topic 1: “Battery Recycling, Mining and Circular Economy” - Material availability and geopolitical dependencies • Extraction processes, sustainability and criticality of raw materials • Recycling processes: Current status, current developments, business models

	• 2nd Life: challenges, matching of 2nd use and battery properties, dis-assembling, diagnostics, business models, regulation <u>Topic 2: "Charging Infrastructure and Energy Markets"</u> • Charging stations, operation, planning, business models, energy markets, electricity grids, vehicle-to-grid, vehicle-to-home, value stacking/multi use • Charging standards, different charging capacities, system architecture of charging stations, grid requirements • Economics of battery charging stations including placement, operation strategy and regulations
Media	RWTHmoodle
Literature	Lecture Slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Economics of Battery Applications and Recycling	5	0	0	See above
Lecture: Economics of Battery Applications and Recycling	0	2	77	0
Exercise: Economics of Battery Applications and Recycling	0	1	39	0

Teaching Unit / Examinations: Examination Economics of Battery Applications and Recycling

Title	Examination Economics of Battery Applications and Recycling
Sub-title	Exa EBAR
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Teaching Unit / Examinations: Lecture Economics of Battery Applications and Recycling

Title	Lecture Economics of Battery Applications and Recycling
Sub-title	L EBAR
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Teaching Unit / Examinations: Exercise Economics of Battery Applications and Recycling

Title	Exercise Economics of Battery Applications and Recycling
Sub-title	E EBAR
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Hardware of Battery Packs & Stationary Applications

Module	Hardware of Battery Packs & Stationary Applications
Module ID	
Module level	Master
Subtitle	HPSA
Lecture	See list of lectures and examinations of the module
Semester allocation	1, 2 or 3
Person in charge	Prof. Dr.-Ing. Stefan Pischinger
Lecturer	Prof. Dr. rer. nat. Dirk Uwe Sauer, Prof. Dr.-Ing. Stefan Pischinger
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	To be admitted to the exam, passing a test (module component) is required.
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • understand the areas of application and the associated requirements • analyze life cycle cost analysis • classify different optimization methods for energy management systems and system sizing • classify the grid support possibilities of batteries • assess of a holistic energy system with a battery storage system and its requirements • analyze the structure and interconnection of battery packs • explain the battery management system architecture • distinguish active and passive balancing systems • inspect mechanical structure and behavior • investigate the recyclability of battery packs • interpret legal requirements

Content	Topic 1: “Battery and Energy Storage Systems in Stationary Applications incl. Life Cycle Cost Analysis” • Battery systems for stationary applications (various fields of application grid-connected, grid-independent, ‘behind the meter’, ‘front of the meter’) • Life cycle cost analysis • Alternatives to battery storage systems • Competition with other flexibilities • Optimization methods for system design • Basics of the energy market & regulation and additional business models • Swarm storage (home storage & traction batteries) • System-optimized use of batteries in the power grid (optimization process, multi-use, value stacking) • Energy management systems • Recyclable design, LCA & circular economy Topic 2: “Battery Pack Design and Battery Management System Hardware” • Mechanical structure of battery packs and system design • Mechanical behavior of cell, module and pack (swelling) • Communication interfaces and measurements • Interconnection, module connections, pack housing, and other passive elements • Advanced battery pack designs like cell2pack • Security aspects and norms and standards • BMS architecture • Active and passive balancing systems • E/E architectures • System integration of pack into vehicle, interaction with vehicle (crush/crash) • Thermal management • Battery safety at system level: thermal propagation / runaway, testing and simulation (cell and pack) • Legal requirements for battery systems
Media	RWTHmoodle
Literature	Lecture slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Hardware of Battery Packs & Stationary Applications	5	0	0	See above
Lecture: Hardware of Battery Packs & Stationary Applications	0	2	77	0

Exercise: Hardware of Battery Packs & Stationary Applications	0	1	39	0

Teaching Unit / Examinations: Examination Hardware of Battery Packs & Stationary Applications	
Title	Examination Hardware of Battery Packs & Stationary Applications
Sub-title	Exa HPSA
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Lecture Hardware of Battery Packs & Stationary Applications	
Title	Lecture Hardware of Battery Packs & Stationary Applications
Sub-title	L HPSA
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Exercise Hardware of Battery Packs & Stationary Applications	
Title	Exercise Hardware of Battery Packs & Stationary Applications
Sub-title	E HPSA
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Module: Understanding Battery Degradation

Module	Understanding Battery Degradation
Module ID	
Module level	Master
Subtitle	UBD
Lecture	See list of lectures and examinations of the module
Semester allocation	1, 2 or 3
Person in charge	Univ.-Prof. Dr. rer. nat. Egbert Figgemeier
Lecturer	Dr.-Ing. Christiane Rahe, Dr. Gebrekidan Eshetu
Language	English
Assignment to the curriculum	Compulsory Elective Module
Recommended requirements	None
Participation requirements (study program specific)	To be admitted to the exam, passing a test (module component) is required.
Teaching form	Examination, Lecture, Exercise
Examination mode	Written Examination (Klausur, 100%, graded)
Workload	Total 150 h, Lecture hours 34 h (3 SWS), Self-study 116 h
Lecture hours	3 SWS
ECTS-Credit Points (CP)	5
Learning objectives	After successful participation in the module course, students are able to: • evaluate ageing tests • understand chemical reactions driving the ageing processes • differentiate between ageing modes and mechanisms • evaluate the importance of operation and storage conditions on the observed ageing
Content	<u>Topic 1: Analysing and quantifying ageing resulting battery testing</u> • Battery ageing ○ Overview Quantitative representation of ageing as a function of operating conditions (macroscopic SEI growth, influence of operating conditions), electrolyte degradation, active material loss, plating) • Calendar ageing and correlation with storage conditions & effects on performance, capacity and safety • Additional cycle ageing effects • Pseudo-ageing (overhang, inhomogenization, etc.)

	• Aging tests - What to consider? <u>Topic 2: Chemistry of Ageing Processes</u> • Decomposition processes • Molecular dynamic modeling • SEI (structure and composition) • Chemical stability window of electrolytes • Structure of solid-state electrolytes • Ionic conductivities • Function of electrolyte components (conductive salts, additives, solvents) • Mechanical cracking of crystals • Solution of transition metals • CEI • Stability and cover layers at current collectors • Ageing of binders • Decomposition of separators • Gas formation and composition
Media	RWTHmoodle
Literature	Lecture slides

Lectures / Examinations

Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Understanding Battery Degradation	5	0	0	See above
Lecture: Understanding Battery Degradation	0	2	77	0
Exercise: Understanding Battery Degradation	0	1	39	0

Teaching Unit / Examinations: Examination Understanding Battery Degradation

Title	Examination Understanding Battery Degradation
Sub-title	Exa UBD
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Teaching Unit / Examinations: Lecture Understanding Battery Degradation

Title	Lecture Understanding Battery Degradation
Sub-title	L UBD

Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module
Teaching Unit / Examinations: Exercise Understanding Battery Degradation	
Title	Exercise Understanding Battery Degradation
Sub-title	E UBD
Semester allocation	1, 2 or 3
Connection to the curriculum	Compulsory Elective Module

Language Courses

Module: Language Course I

Module	Language Course I
Module-ID	4021266
Module level	Master
Subtitle	LC 1
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	RWTH Aachen University Language Center
Lecturer	-
Language	German (if not proficient/native speaker)
Assignment to the curriculum	Compulsory Module
Recommended requirements	-None-
Participation requirements (study program specific)	-None-
Teaching form	Examination, Lecture, Exercise
Examination mode	100% written examination in reading, listening, writing and grammar
Workload	Total 60 h, Lecture hours 23 h (2 SWS), Self-study 37 h
Lecture hours	23 h (2 SWS)
ECTS-Credit Points (CP)	2
Learning Objectives	Students shall learn the basics of the respective language or deepen and expand already existing skills for active participation in everyday and working life.
Content	The course is aimed at students who are looking for a university-specific foreign language education, who need a foreign language for their studies, and/or are planning a stay abroad (study, internship, project). Depending on the level, the range of foreign languages on offer considers the training of language skills specific to the profession. In the course you will learn the essential elements of grammar and vocabulary of the respective language, depending on your level, so that you can assert yourself both in writing and orally in everyday communication

	situations. In addition, you will learn to extract the essential information from authentic and university-specific reading and listening texts as well as from various types of texts such as: Write e-mails, letters, messages, and notes.

Lectures / Examinations

Title	ECTS	Workload		Duration of Exam (min)
		Lecture h. (SWS)	Self-Study (h)	
Examination: Language Course I	2	0	0	See examination options
Lecture: Language Course I	0	1	33,5	0
Exercise: Language Course I	0	1	33,5	0

Teaching Unit / Examinations: Examination Language Course I

Title	Examination Language Course I
Sub-title	Exa LC I
Semester allocation	1
Connection to the curriculum	Compulsory Module

Teaching Unit / Examinations: Lecture Language Course I

Title	Lecture Language Course I
Sub-title	L LC I
Semester allocation	1
Connection to the curriculum	Compulsory Module

Teaching Unit / Examinations: Exercise Language Course I

Title	Exercise Language Course I
Sub-title	E LC I
Semester allocation	1
Connection to the curriculum	Compulsory Module

Module: Language Course II

Module	Language Course II
Module-ID	4021267
Module level	Master
Subtitle	LC II
Lecture	See list of lectures and examinations of the module
Semester allocation	1
Person in charge	RWTH Aachen University Language Center
Lecturer	-
Language	German (if not proficient/native speaker)
Assignment to the curriculum	Compulsory Module
Recommended requirements	-None-
Participation requirements (study program specific)	-None-
Teaching form	Examination, Lecture, Exercise
Examination mode	100% written examination in reading, listening, writing and grammar
Workload	Total 60 h, Lecture hours 23 h (2 SWS), Self-study 37 h
Lecture hours	23 h (2 SWS)
ECTS-Credit Points (CP)	2
Learning Objectives	Students shall learn the basics of the respective language or deepen and expand already existing skills for active participation in everyday and working life.
Content	The course is aimed at students who are looking for a university-specific foreign language education, who need a foreign language for their studies, and/or are planning a stay abroad (study, internship, project). Depending on the level, the range of foreign languages on offer considers the training of language skills specific to the profession. In the course, you will learn the essential elements of grammar and vocabulary of the respective language, depending on your level, so that you can assert yourself both in writing and orally in everyday communication situations. In addition, you will learn to extract the essential information from

	authentic and university-specific reading and listening texts as well as from various types of texts such as: Write e-mails, letters, messages, and notes.

Lectures / Examinations				
Title	**ECTS**	**Workload**		**Duration of Exam (min)**
		Lecture h. (SWS)	**Self-Study (h)**	
Examination: Language Course II	2	0	0	See examination options
Lecture: Language Course II	0	1	33,5	0
Exercise: Language Course II	0	1	33,5	0

Teaching Unit / Examinations: Examination Language Course II	
Title	Examination Language Course II
Sub-title	Exa LC II
Semester allocation	1
Connection to the curriculum	Compulsory Module

Teaching Unit / Examinations: Lecture Language Course II	
Title	Lecture Language Course II
Sub-title	L LC II
Semester allocation	1
Connection to the curriculum	Compulsory Module

Teaching Unit / Examinations: Exercise Language Course II	
Title	Exercise Language Course II
Sub-title	E LC II
Semester allocation	1
Connection to the curriculum	Compulsory Module

Master Thesis

Module: Master Thesis

Module	Master Thesis
Module ID	
Module level	Master
Subtitle	MaTh
Semester	4
Language	English
Assignment to the curriculum	Compulsory Module
Recommended requirements	none
Participation requirements (study program specific)	The topic of the master thesis cannot be assigned until 70 CP have been successfully completed.
Examination mode	Master Thesis (100 %, graded) and Colloquium (not graded)
Workload	6 Months
ECTS-Credit Points (CP)	30
Learning objectives	The students learn to independently approach and process academic themes, document them, and interpret them in writing within a set deadline. They also acquire systematic academic research skills.
Content	Completed academic paper, which shows that the students are capable of independently processing a problem related to their subject according to academic methods within a set deadline.