Technische Hochschule Nürnberg

Master's programme
Computational Mechanical Engineering
M-CME

Module catalogue

Technische Hochschule Nürnberg
Georg Simon Ohm
Faculty of Mechanical Engineering and Supply Engineering

Document information

Version

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Validity
For all students who commenced their studies at Technische Hochschule Nürnberg Georg Simon Ohm University of Applied Sciences from the 2026/2027 winter semester onwards.

Content developed by the teaching staff of the Master's programme in Computational Mechanical Engineering and checked for completeness by the Faculty Council of the Faculty of Mechanical Engineering and Building Services Engineering at Technische Hochschule Nürnberg – Georg Simon Ohm University of Applied Sciences by resolution of 22 April 2026.

Prof. Dr Michael Koch,
Dean

The module handbook is issued on the basis of

— Section 84(3), sentences 1 and 2 of the Bavarian Higher Education Innovation Act (BayHIG) of 5 August 2022 (GVBl. p. 414, BayRS 2210-1-3-WK), as last amended by Section 1 of the Act of 23 July 2024 (GVBl. p. 257),

— Section 16(1), sentences 5 and 6, and (2), sentence 2, of the General Study and Examination Regulations of the Technische Hochschule Nürnberg Georg Simon Ohm, dated 29 June 2023 (Official Gazette of the Technische Hochschule Nürnberg Georg Simon Ohm, Nuremberg 2023, serial no. 18; ► www.th-nuernberg.de),

— the Study and Examination Regulations for the Master's programme in Computational Mechanical Engineering at the Technische Hochschule Nürnberg Georg Simon Ohm University of Applied Sciences dated 9 December 2025 (Official Gazette of the Technische Hochschule Nürnberg Georg Simon Ohm University of Applied Sciences 2025, serial no. 48; ► www.th-nuernberg.de) as well as

— the curriculum for the Bachelor's degree programme in Mechanical Engineering at the Technische Hochschule Nürnberg Georg Simon Ohm, Nuremberg

Table of Contents

Overview

Abbreviations and Explanations

List of abbreviations

Sem	Semester
,	and
/	or
;	and / or
SWS	Hours per week
LP	Credit points under the European Credit Transfer and Accumulation System (ECTS)
Course	Course
…	Abbreviations for courses
H	Lesson
…	Abbreviations for examination formats

— ECTS credits are indicated according to the following scheme: ECTS credits printed in brackets represent the number of credits per sub-module or sub-exam and are used for calculation purposes. ECTS credits not in brackets indicate the total number of ECTS credits that can be earned within the relevant module.

— Please note: The module handbook serves to supplement and expand upon the Study and Examination Regulations (SPO) and the curriculum in their currently valid versions.

— The SPO and the curriculum in their respective versions are available at the following URL: https://www.th-nuernberg.de/fakultaeten/mb-vs/studium/master-computational-mechanical-engineering-msc/

— SPO: https://www.th-nuernberg.de/fileadmin/zentrale-einrichtungen/szs/sb/sb_docs/SPOs/Maschinenbau_und_Versorgungstechnik/Master/spoM-CME_aktuell.pdf

— Curriculum: https://www.th-nuernberg.de/fakultaeten/mb-vs/studium/master-computational-mechanical-engineering-msc/

Study objectives and Competence profile

Programme objective

The aim of the Master's programme in Computational Mechanical Engineering is to train students to become highly qualified engineers who are capable of thoroughly analysing, modelling and optimising complex mechanical systems using modern computer-aided methods. The programme deepens and broadens the fundamental engineering knowledge acquired during the Bachelor's degree, particularly in the areas of numerical methods, computer-aided engineering (CAE), simulation, modelling and data-based analysis methods.
Graduates possess in-depth technical and methodological expertise to tackle challenging problems in research, development and industrial practice independently, systematically and on a sound scientific basis. They are able to formulate physical-mathematical models, select suitable numerical solution methods, and critically evaluate, validate and incorporate simulation results into technical decision-making processes.
Furthermore, the programme fosters the ability to work in an interdisciplinary manner, to critically reflect on one's own approaches to problem-solving, and to communicate complex technical issues in a structured manner within international and intercultural contexts. Graduates are equipped to take on managerial roles in development, calculation and simulation, or to pursue an academic career, including a PhD.

e learning outcomes to be achieved through the programme

In accordance with the recommendations of the 'Accreditation Agency for Degree Programmes in Engineering, Computer Science, Natural Sciences and Mathematics e.V.' (ASI IN), the modules of the Master's programme cover the following categories:

- Specialist specialisation modules (Core Modules)
- Compulsory elective modules / Profile development areas
- Methodological and scientific competences
- Practical, project and research components
- Master's thesis (including colloquium)

The following overview assigns the individual modules/sub-modules of the curriculum to these categories and explains the learning outcomes to be achieved in this context.

Compulsory modules (30 ECTS)

The compulsory modules form the **scientific and methodological foundation** of the programme. They provide in-depth knowledge in the fields of mathematics, numerical methods, mechanics, fluid mechanics and data-driven methods.

Module	Category
Selected Topics of Mathematics and Numerics	Advanced Topics / Methods
The Finite Element Method / Theory of the Finite Element Method	Specialist Advanced Topics / Methods
Advanced Engineering Mechanics / Advanced Engineering Mechanics	Specialist Advanced Topics
Advanced Mechanics of Materials / Advanced Mechanics of Materials	Specialist specialisation
Computational Fluid Dynamics / Computational Fluid Dynamics	Specialist specialisation / Methods
Machine Learning	Methodological and scientific

Compulsory elective modules (min. 30 ECTS)

The compulsory elective area allows students to **develop** an **individual profile** with specialisation in simulation, product development, materials, bionics, thermodynamics or statistics. The elective modules are thematically coherent and clearly aligned with the *Computational Mechanical Engineering* profile.

Module examples	Category
Simulation Methods / Simulation Techniques	Specialist specialisation / Methods
Multi-Physics Simulation	Specialist specialisation / Methods
Noise, Vibration and Harshness	Specialist specialisation
Bio-inspired Engineering / Bionics	Specialist specialisation
New metallic materials	Specialist specialisation
Product Development Practice	Profile Development / Application
Statistics	Methodological and scientific

Project modules (compulsory elective area, 5 to 15 ECTS)

The project modules are designed to provide **application- and research-oriented specialisation**. They encourage independent work and the tackling of complex, open-ended problems.

Module	Category
Small-scale project (5 ECTS)	Project
Major project (10 ECTS)	Project
Research project (15 ECTS)	Project / Research

Master's Thesis and Master's Seminar (30 ECTS)

The Master's thesis forms the **academic focus of the programme** and demonstrates the ability to independently tackle a complex engineering problem.

Module	Category
Master's thesis (28 ECTS)	Research output
Master's seminar / colloquium (2 ECTS)	Academic Communication

Competence-to-module mapping

The competence objectives are based on the areas defined in the curriculum:

- Subject-specific competences
- Methodological competences
- Personal and social competences

Technical competences

Objective: In-depth engineering knowledge in computer-aided mechanical engineering and the simulation of complex systems.
Primary modules:

- Advanced Engineering Mechanics
- Advanced Mechanics of Materials
- The Finite Element Method
- Computational Fluid Dynamics
- Multi-Physics Simulation
- Noise, Vibration and Harshness
- Bio-inspired engineering
- New metallic materials
- Advanced Technical Thermodynamics

The modules provide a scientifically sound understanding of complex physical relationships and their computer-aided description.

Methodological skills

Objective: Ability to model, numerically solve, evaluate and validate complex engineering problems.
Primary modules:

- Selected Topics in Mathematics and Numerics
- The Finite Element Method
- Simulation Methods
- Statistics
- Machine Learning
- Multi-Physics Simulation
- Computational Fluid Dynamics

Students learn to systematically select, apply and critically evaluate suitable methods.

Personal and social skills

Objective: Independent working, teamwork and communication skills, as well as a sense of responsibility in scientific and industrial environments.
Primary modules:

- Project work (W9–W11)
- Product Development Practice
- Master’s thesis
- Master’s seminar / colloquium

Particular emphasis is placed on initiative, teamwork, presentation skills and academic reasoning.

Part 1

Compulsory modules

1 Module P1-d: Selected Topics in Mathematics and Numerics

Module title	DE	P1-d: Selected Chapters in Mathematics and Numerics			ECTS	5
	EN					
Module number						
Module responsibility	Prof. Dr Papastavrou					
Lecturers *(optional)*	Prof. Dr Papastavrou					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes			

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Selected topics in mathematics and numerical analysis	Summer term only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Selected chapters in mathematics and numerical methods	Summer term only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon completion of the course, students will be able to • select and apply mathematical methods and numerical simulation techniques in a targeted manner to model and solve technical problems independently.

- apply suitable discretisation methods with confidence, critically assess their limitations, and evaluate the numerical results with technical expertise.

formulate and implement numerical methods algorithmically so that they can serve as a basis for the development of their own computer programmes.

Course content	- Stability, consistency, convergence - Iterative methods for solving systems of linear equations - Interpolation with splines - Multi-step methods for solving ordinary differential equations - Finite difference methods for partial differential equations - Introduction to the finite element method for elliptic problems		
Requirements for the award of ECTS	Pass the examination(s)		
Examination	Selected chapters in mathematics and numerical methods		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	…		
Other information	…		
References	H.R. Schwarz, N. Köckler: Numerical Mathematics, Vieweg and Teubner		

2 Module P1-e: Selected Topics of Mathematics and Numerics

Module title	DE	…			ECTS	5
	EN	P1-e: Selected Topics in Mathematics and Numerics				
Module number						
Module Responsibility	Prof. Dr Papastavrou					
Lecturers *(optional)*	Prof. Dr Papastavrou					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes			

Associated module components						
Teaching method	Name	Frequency	Contact (contact hours)	Self-study	ECTS	Semester
Seminar-based teaching	Selected Topics in Mathematics and Numerics	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Seminar	Selected Topics in Mathematics and Numerics	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to

	• analyse, select and apply mathematical methods and numerical simulation techniques in depth in order to model technical problems appropriately and solve them numerically. • to use discretisation methods confidently, to critically assess their suitability and limitations, and to evaluate the quality and plausibility of the numerical results obtained on a sound technical basis. structuring and implementing various numerical methods algorithmically so that they can serve as a basis for the development, implementation and extension of computer programmes.
Course content	• Stability, consistency, convergence • Iterative methods for solving systems of linear equations • Interpolation with splines • Multi-step methods for solving ordinary differential equations • Finite difference methods for partial differential equations • Introduction to the finite element method for elliptic problems
Requirements for the award of ECTS	Pass the examination(s)

Examination	Selected Topics in Mathematics and Numerics		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	…		

Other information	…
References	H.R. Schwarz, N. Köckler: Numerical Mathematics, Vieweg and Teubner

3 Module P2-d: Theory of the Finite Element Method

Module title	DE	P2-d: Theory of the Finite Element Method			ECTS	5
	EN					
Module number						
Module Responsibility	Prof. Dr Vogel-Brinkmann					
Lecturers *(optional)*	Prof. Dr Vogel-Brinkmann					
Assignment to the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 1					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes			

Associated module components						
Teaching method	Name	Frequency	Face-to-face (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Theory of the Finite Element Method	Winter semester only	33.75 hours (3 contact hours per week)	78.75 hours	3.75	1
Practical	Theory of the Finite Element Method	Winter semester only	11.25 hours (1 contact hour)	26.5 hours	1.25	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • explain, contextualise and apply the theoretical principles of the finite element method (FEM) to specific problems.

- formulate and implement steady-state and transient field problems using the FEM, and account for non-linearities in structural mechanics in a methodologically correct manner.
- apply the finite element method independently to engineering problems, interpret the results with technical expertise, and
- critically analyse and evaluate the capabilities, limitations, and advantages and disadvantages of the method.

Course content	Mathematical modelling using partial differential equations in the fields of heat conduction and elasticity; relevant components from continuum mechanics, tensor calculus and functional analysis; strong and weak formulations of PDEs; Boundary conditions; isoparametric element formulations, basis functions and coordinate transformations; aspects of implementation: data structures, numerical integration and matrix assembly, post-processing of the numerical solution; consideration of material and geometric non-linearities; linear continuum elements in structural mechanics; locking phenomena, mixed methods and reduced integration.
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Theory of the Finite Element Method		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	Recommended prior knowledge: Technical mechanics, numerical methods, basic programming skills		

Other information	
References	Bathe, K.-J.: Finite Element Procedures. Braess, D.: Finite Elements. Theory, Fast Solvers and Applications in Elasticity Theory. Brenner, S. C.; Scott, L. R.: The Mathematical Theory of Finite Element Methods. Hughes, T. J. R.: The Finite Element Method: Linear Static and Dynamic Finite Element Analysis. Zienkiewicz, O. C.; Taylor, R. L.; Zhu, J. Z.: The Finite Element Method: Its Basis and Fundamentals. Belytschko, T.; Liu, W. K.; Moran, B.; Elkhodary, K.: Nonlinear Finite Elements for Continua and Structures. Quarteroni, A.; Valli, A.: Numerical Approximation of Partial Differential Equations. Strang, G.; Fix, G. J.: An Analysis of the Finite Element Method

4 Module P2-e: The Finite Element Method

Module title	DE	ECTS 5
	EN P2-e: The Finite Element Method	
Module number		
Module responsibility	Prof. Dr Vogel-Brinkmann	
Lecturers *(optional)*	Prof. Dr Vogel-Brinkmann	
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)	
Stage in the course of study	Standard semester: 2	
Duration of the module	1 semester	
Language of instruction	☐ German ☒ English	
Contribution to the StG's qualification objectives (optional)	…	Applicability of the module in other degree programmes

Associated module components						
Teaching method	Name	Frequency	Face-to-face (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	The Finite Element Method	Summer semester only	33.75 hours (3 contact hours per week)	78.75 hours	3.75	1
Practical	The Finite Element Method	Summer semester only	11.25 hours (1 contact hour)	26.5 hours	1.25	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • explain and contextualise the theoretical foundations of the finite element method (FEM) and apply them to specific problems.

- formulate and implement steady-state and transient field problems using the FEM, and account for non-linearities in structural mechanics in a methodologically correct manner.
- apply the finite element method independently to engineering problems, interpret the results with technical expertise, and

critically analyse and evaluate the capabilities, limitations, and advantages and disadvantages of the method.

Course content	Mathematical modelling using partial differential equations in the fields of heat conduction and elasticity; relevant components from continuum mechanics, tensor calculus and functional analysis; strong and weak formulations of PDEs; Boundary conditions; isoparametric element formulations, basis functions and coordinate transformations; aspects of implementation: data structures, numerical integration and matrix assembly, post-processing of the numerical solution; consideration of material and geometric non-linearities; linear continuum elements in structural mechanics; locking phenomena, mixed methods and reduced integration.		
Prerequisites for the award of ECTS	Pass the examination(s)		
Examination	The Finite Element Method		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	Recommended prior knowledge: Technical mechanics, numerical methods, basic programming skills		
Other information	…		
References	Bathe, K.-J.: Finite Element Procedures. Braess, D.: Finite Elements. Theory, Fast Solvers and Applications in Elasticity Theory. Brenner, S. C.; Scott, L. R.: The Mathematical Theory of Finite Element Methods. Hughes, T. J. R.: The Finite Element Method: Linear Static and Dynamic Finite Element Analysis. Zienkiewicz, O. C.; Taylor, R. L.; Zhu, J. Z.: The Finite Element Method: Its Basis and Fundamentals. Belytschko, T.; Liu, W. K.; Moran, B.; Elkhodary, K.: Nonlinear Finite Elements for Continua and Structures. Quarteroni, A.; Valli, A.: Numerical Approximation of Partial Differential Equations. Strang, G.; Fix, G. J.: An Analysis of the Finite Element Method		

5 Module P3-d: Advanced Engineering Mechanics

Module title	EN	P3-d: Advanced Engineering Mechanics			ECTS	5
	EN					
Module number						
Module responsibility	Prof. Dr Ertz					
Lecturers *(optional)*	Prof. Dr Ertz					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Advanced Technical Mechanics	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Advanced Technical Mechanics	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • analyse and apply concepts and methods of engineering mechanics at an advanced level in order to describe and solve complex mechanical problems appropriately.

- explain the fundamental theoretical concepts of the finite element method (FEM), formulate them mathematically and apply them to mechanical problems.
- apply tensor calculus confidently to represent mechanical quantities concisely and handle three-dimensional mechanical problems formally correctly.
- to investigate specific mechanical systems mathematically, interpret the results physically and critically assess their significance.
- to use computer-aided tools, in particular MATLAB, in a targeted manner to numerically solve problems from advanced technical mechanics, visualise results and evaluate them.

Course content	• Linear continuum mechanics: tensor calculus, deformation and strain tensors, balance equations, linear elasticity • Introduction to the theory of the finite element method: approximation methods, one- and two-dimensional finite elements, discretisation, numerical integration, project-based work in MATLAB • Principle of virtual work in statics, elastostatics and kinetics, principles of mechanics: Castigliano's theorem, Lagrange's equations, D'Alembert's principle • Selected chapters from the following topics: ○ Vibrations ○ Continuum mechanics ○ Linear fracture mechanics		
Requirements for the award of ECTS	Pass the examination(s)		
Examination	Advanced Technical Mechanics		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Type of assessment	Graded	Weighting	-
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	…		
Other information	…		
References	Dresig, Holzweißig: Machine Dynamics, Springer Vieweg Gonzalez, Stuart: A First Course in Continuum Mechanics, Cambridge Texts in Applied Mathematics Gross et al.: Engineering Mechanics 3, Springer Vieweg Holzapfel: Nonlinear Solid Mechanics, Wiley Mang, Hofstetter: Strength of Materials, Springer Vieweg		

6 Module P3-e: Advanced Engineering Mechanics

Module title	DE	…			ECTS	5
	EN	P3-e Advanced Engineering Mechanics				
Module number						
Module Responsibility	Prof. Dr Boy					
Lecturers *(optional)*	Prof. Dr Boy					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 1					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes			

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Advanced Engineering Mechanics	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Advanced Engineering Mechanics	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	By the end of the semester, students will be able to: • To describe the rotation of rigid bodies mathematically and to implement this numerically for specific examples. To identify and mathematically define basic

concepts of continuum mechanics (e.g. body, position, deformation). To derive the equations of motion subject to constraints for mass points and rigid bodies (during rotation about a fixed axis). Classify different types of constraints. Illustrate the concepts of configuration space, constraint and generalised coordinate using examples to . Perform analytical variational calculations for simple mathematical examples. Use the principle of virtual work to calculate support reactions. Use the principle of virtual work to derive equations of motion for systems with constraints. Apply the second-order Lagrange equations to derive equations of motion for realistic engineering problems. Use Hamilton's principle to derive equations of motion for 1D continua (rods, strings, beams). Explain the statements of Noether's theorem using examples.

- Select mechanical methods specifically to solve technical problems. Translate technical situations into mathematical models. Independently apply strategies for simplification and approximation.
- Develop and communicate approaches and solutions in a structured manner, either in a group or independently. Review given solutions to mechanical problems and provide constructive feedback to improve calculation methods or solutions.
- Identify gaps in one's own understanding and actively address them (e.g. with the help of specialist literature). Develop learning strategies to enable one to understand even complex and/or complicated issues. Systematically analyse and correct mistakes made.

Course content	Fundamentals of spatial kinematics and kinetics of rigid bodies, basic concepts of continuum mechanics, motion under constraints (Lagrange equations of the first kind), fundamentals of the calculus of variations, principle of virtual work (statics and dynamics), Lagrange formalism (Lagrange equations of the second kind), Hamilton's principle with application to vibrations of rods, plates and beams), conservation laws and Noether's theorem.		
Prerequisites for the award of ECTS	Pass the examination(s)		
Examination	Advanced Engineering Mechanics		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	…		
Other information	…		
References	Lanczos: The Variational Principles of Mechanics, Dover Publications, New York, USA. Goldstein, Poole, Safko: Classical Mechanics, Pearson, Harlow, UK.		

7 Module P4-d: Advanced Strength of Materials

Module title	DE	P4-d: Advanced Strength of Materials			ECTS	5
	EN					
Module number						
Module responsibility	Prof. Dr Ertz					
Lecturers *(optional)*	Prof. Dr Ertz					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 1					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	Name	Frequency	Contact (contact hours)	Self- self-study	ECTS	Semester
Seminar-based teaching	Advanced Strength of Materials	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Advanced Strength of Materials	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to

- describe displacements, distortions and stresses as state variables in structural mechanics problems in a technically accurate manner, as well as derive, classify and apply the underlying fundamental equations and boundary conditions.
- independently model and solve structural mechanics problems using the finite element method (FEM), applying their in-depth knowledge of FEM in a targeted manner.
- critically analyse and qualitatively assess numerical FEM results, particularly with regard to plausibility, accuracy and method-related limitations.
- Apply validation methods in a targeted manner using simple analytical models to understand, verify and systematically evaluate the behaviour of specific FEM calculation methods.

Course content	Fundamentals of elasticity theory: state variables, fundamental equations, boundary conditions, analytical solutions for simple cases, energy principles. Non-linearities due to elastoplastic material behaviour, large deformations and contact problems. Application of the FEM in linear and non-linear structural mechanics: analysis of the problem, modelling, control of the calculation process, evaluation and assessment of results, comparison of results with analytical estimates.		
Prerequisites for the award of ECTS	Pass the examination(s)		
Examination	Advanced Strength of Materials		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	…		
Other information	…		
References	Issler, L., Ruoß, H., Häfele, P.: Fundamentals of Strength of Materials. Springer Verlag Göldner, H.: Advanced Strength of Materials. Fachbuchverlag Leipzig Hahn, H. G.: Theory of Elasticity. Teubner-Verlag, Stuttgart. Klein, B.: FEM – Fundamentals and Applications of the Finite Element Method in Mechanical and Vehicle Engineering. Vieweg-Verlag Rust, W.: Non-linear Finite Element Calculations. Vieweg+Teubner Gebhardt, Chr.: Practical Guide to FEM with ANSYS Workbench. Carl Hanser Verlag		

8 Module P4-e: Advanced Mechanics of Materials

Module title	DE				ECTS	5
	EN	P4-e: Advanced Mechanics of Materials				
Module number						
Module Responsibility	Prof. Dr Papastavrou					
Lecturers *(optional)*	Prof. Dr Papastavrou					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 1					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		
Associated module components						

Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Advanced Mechanics of Materials	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Advanced Mechanics of Materials	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to

- describe displacements, distortions and stresses as state variables in structural mechanics problems in a technically accurate manner, as well as derive, classify and apply the underlying fundamental equations and boundary conditions.
- independently model and solve structural mechanics problems using the finite element method (FEM), applying their in-depth knowledge of FEM in a targeted manner.
- critically analyse and qualitatively assess numerical FEM results, particularly with regard to plausibility, accuracy and method-related limitations.

Apply validation methods in a targeted manner using simple analytical models to understand, verify and systematically evaluate the behaviour of specific FEM calculation methods.

Course content	Fundamentals of elasticity theory: state variables, fundamental equations, boundary conditions, analytical solutions for simple cases, energy principles. Non-linearities due to elastoplastic material behaviour, large deformations and contact problems. Application of the FEM in linear and non-linear structural mechanics: analysis of the problem, modelling, control of the calculation process, evaluation and assessment of results, comparison of results with analytical estimates.		
Prerequisites for the award of ECTS	Pass the examination(s)		
Examination	Advanced Mechanics of Materials		
Exam type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	…		
Other information	…		
References	Issler, L., Ruoß, H., Häfele, P.: Fundamentals of Strength of Materials. Springer Verlag Göldner, H.: Advanced Strength of Materials. Fachbuchverlag Leipzig Hahn, H. G.: Theory of Elasticity. Teubner-Verlag, Stuttgart. Klein, B.: FEM – Fundamentals and Applications of the Finite Element Method in Mechanical and Vehicle Engineering. Vieweg-Verlag Rust, W.: Non-linear Finite Element Calculations. Vieweg+Teubner Gebhardt, Chr.: Practical Guide to FEM with ANSYS Workbench. Carl Hanser Verlag		

9 Module: P5-d – Computational Fluid Dynamics

Module title	DE	P5-d – Computational Fluid Dynamics			ECTS	5
	EN	…				
Module number						
Module responsibility	Prof. Dr Markus Schmid					
Lecturers *(optional)*	Prof. Dr Markus Schmid					
Affiliation with the degree programme	Master’s in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 1					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the StG’s qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master’s in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Computational Fluid Dynamics	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	(2.5)	1
Practical	Numerical Fluid Mechanics	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	(2.5)	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	(5)	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • explain the fundamental equations of fluid mechanics accurately, contextualise them and apply them to fluid mechanics problems.

	• present the fundamentals of computational fluid dynamics (CFD) in a structured manner and explain its theoretical assumptions and areas of application. • describe fundamental concepts of turbulence modelling, compare different modelling approaches and critically assess their applicability. • systematically design computational fluid dynamics simulations for engineering problems, including modelling, boundary conditions and solution strategies. • Select suitable solvers and turbulence models depending on the problem and justify their choice from a technical perspective. • Critically analyse and evaluate the results of numerical flow simulations, particularly with regard to physical plausibility, model limitations and numerical accuracy.
Course content	• Treatment of the fundamental equations of fluid mechanics (continuity equation, Navier-Stokes equations) • Fundamentals of numerical flow simulation methods (finite differences, finite volumes) • Methods for solving unsteady flows • Methods for solving systems of equations • Methods for the numerical solution of the Navier-Stokes equations (pressure correction methods, SIMPLE/PISO algorithm) • Methods for turbulence modelling, wall functions • Practical exercises using modern CFD software
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Numerical fluid mechanics		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	…		

Other information	…
References	Ferziger, Peric: Numerical Fluid Mechanics, Springer Oertel: Fluid Mechanics, Vieweg+Teubner Oertel, Laurien: Numerical Fluid Mechanics, Vieweg+Teubner

10 Module: P5-e – Computational Fluid Dynamics

Module title	DE	…			ECTS	5
	EN	P5-e – Computational Fluid Dynamics				
Module number						
Module Responsibility	Prof. Dr Markus Schmid					
Lecturers *(optional)*	Prof. Dr Markus Schmid					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 1					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the qualification objectives of the StG (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components

Teaching format	Name	Frequency	Contact Classroom-based study (SWS)	Self-Self-study	ECTS	Semester
Seminar-based teaching	Computational Fluid Dynamics	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	(2.5)	1
Practical	Computational Fluid Dynamics	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	(2.5)	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	(5)	

Compulsory attendance	Compulsory module
Prerequisites for participation	

Learning objectives	Upon successful completion of the course, students will be able to • explain the fundamental equations of fluid mechanics accurately, contextualise them and apply them to fluid mechanics problems. • present the fundamentals of computational fluid dynamics (CFD) in a structured manner and explain its theoretical assumptions and areas of application. • describe fundamental concepts of turbulence modelling, compare different modelling approaches and critically assess their applicability. • systematically design computational fluid dynamics simulations for engineering problems, including modelling, boundary conditions and solution strategies. • Select suitable solvers and turbulence models depending on the problem and justify their choice from a technical perspective. Critically analyse and evaluate the results of numerical flow simulations, particularly with regard to physical plausibility, model limitations and numerical accuracy.
Course content	• Treatment of the fundamental equations of fluid mechanics (continuity equation, Navier-Stokes equations) • Fundamentals of numerical flow simulation methods (finite differences, finite volumes) Methods for solving unsteady flows • Methods for solving systems of equations • Methods for the numerical solution of the Navier-Stokes equations (pressure correction methods, SIMPLE/PISO algorithm) • Methods for turbulence modelling, wall functions • Practical exercises using modern CFD software
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Computational Fluid Dynamics		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	…		

Other information	…
References	Ferziger, Peric: Computational Methods for Fluid Dynamics, Springer Oertel: Fluid Mechanics, Vieweg+Teubner Oertel, Laurien: Numerical Fluid Mechanics, Vieweg+Teubner

11 Module: P6-d – Machine Learning

Module title	DE	P6-d – Machine Learning	ECTS	5
	EN	…		
Module number				
Module Responsibility	Prof. Dr Adrian			
Lecturers *(optional)*	Dr Springer			
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)			
Stage in the course of study	Standard semester: 2			
Duration of the module	1 semester			
Language of instruction	☒ German ☐ English			
Contribution to the StG's qualification objectives (optional)	…	Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)	

Associated module components

Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Machine learning	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Machine Learning	Summer term only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon completion of the course, students will be able to: • understand typical machine learning algorithms,

	• • read and comprehend the associated Python code (including Scikit-Learn and TensorFlow code) • apply these algorithms and the relevant code to similar problems • and thus develop their own initial machine learning models • This knowledge is consolidated through programming exercises on TensorFlow-capable GPU computers (computer lab) and illustrated by practical examples from the automotive industry (Audi, VW, Ducati). Following participation in the ‘ ’, students will also have a level of knowledge that enables them to continue their education in the field of AI independently, attend advanced AI courses on well-known online portals and, where applicable, complete nanodegrees.
Course content	The first part of the lecture focuses on the following machine learning approaches: • Linear and logistic regression • Multilayer perceptron • Feed-forward neural networks In the second part of the lecture, the knowledge acquired will be used to explain the technology behind ChatGPT. The focus here will be on the following approaches: • N-gram language models, embeddings • Large Language Models (LLMs) • ChatGPT By the end of the lecture, students will have gained an understanding of machine learning in general, and of neural networks and language models in particular. All exercises and the term paper contribute step-by-step towards this goal and build the ability to write one’s own programme code using the approaches outlined above.
Prerequisites for the award of ECTS credits	Pass the examination(s)

Exam	Machine learning		
Exam type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	…		

Other information	…
References	I. Goodfellow, Y. Bengio, A. Courville, “Deep Learning”, MIT Press, Cambridge M. Bishop, “Pattern Recognition and Machine Learning”, Springer Verlag, Berlin

12 Module: P6-e – Machine Learning

Module title	DE				ECTS	5
	EN	P6-e – Machine Learning				
Module number						
Module responsibility	Prof. Dr Adrian					
Lecturers *(optional)*	Dr Springer					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Machine Learning	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Machine Learning	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory module
Prerequisites for participation	
Learning objectives	Upon completion, students will be able to: • understand typical machine learning algorithms,

	• • read and comprehend the associated Python code (including Scikit-Learn and TensorFlow code) • apply these algorithms and the relevant code to similar problems • and thus develop your own initial machine learning models This knowledge is consolidated through programming exercises on TensorFlow-capable GPU computers (computer lab) and illustrated by practical examples from the automotive industry (Audi, VW, Ducati). After completing the course , students will also have a level of knowledge that enables them to continue their education in the field of AI independently, attend advanced AI courses on well-known online portals and, where applicable, complete nanodegrees.
Course content	The first part of the lecture focuses on the following machine learning approaches: • Linear and logistic regression • Multilayer perceptron • Feed-forward neural networks In the second part of the lecture, the knowledge acquired will be used to explain the technology behind ChatGPT. The focus here will be on the following approaches: • N-gram language models, embeddings • Large Language Models (LLMs) • ChatGPT By the end of the lecture, students will have gained an understanding of machine learning in general, and of neural networks and language models in particular. All exercises and the term paper contribute step-by-step towards this goal and build the ability to write one's own programme code using the approaches outlined above.
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Machine Learning		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☐ German ☒ English	Attendance record	No
Additional information	…		

Other information	…
References	I. Goodfellow, Y. Bengio, A. Courville, "Deep Learning", MIT Press, Cambridge M. Bishop, "Pattern Recognition and Machine Learning", Springer Verlag, Berlin

Part 2

Compulsory elective modules

13 Module: W1-d – Simulation Techniques

Module title	DE	W1-d – Simulation Techniques			ECTS	5
	EN	…				
Module number						
Module responsibility	Prof. Dr Vogel-Brinkmann					
Lecturers *(optional)*	Prof. Dr Vogel-Brinkmann and pool of lecturers					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semesters: 1, 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the qualification objectives of the StG (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components

Teaching format	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Lecture	Simulation techniques	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Simulation techniques	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (2 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to

- explain numerical simulation methods accurately and distinguish systematically between the algorithms derived from them.
- apply suitable numerical methods to solve technical problems and select and justify the solution strategy depending on the problem.
- design algorithms for numerical methods and translate them into a computer programme, resulting in executable and functional code.
- critically evaluate the results of numerical calculations, particularly with regard to the validity, stability and significance of the numerical solution.

Course content	Definition of simulation technology and numerical methods Iterative methods for solving systems of linear equations Solving non-linear algebraic systems of equations Linear and non-linear optimisation Time integration of ordinary differential equations Discretisation methods for partial differential equations Programming and application of numerical solution strategies Evaluation of numerical results and comparison with the analytical solution using selected examples		
Prerequisites for the award of ECTS	Pass the examination(s)		
Examination	Simulation techniques		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	Recommended prior knowledge: Numerical methods, basic programming skills		
Other information	Also offered in English in the M-CME		
Further reading	H.R. Schwarz, N. Köckler: Numerical Mathematics, Vieweg and Teubner H. W. Hamacher, K. Klamroth: Linear Optimisation and Network Optimisation, Vieweg		

14 Module: W1-e – Simulation Methods

Module title	DE				ECTS	5
	EN	W1-e – Simulation Methods				
Module number						
Module Responsibility	Prof. Dr Vogel-Brinkmann					
Lecturers *(optional)*	Prof. Dr Vogel-Brinkmann and pool of lecturers					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semesters: 1, 2					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Lecture	Simulation Methods	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Simulation Methods	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (2 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • explain numerical simulation methods accurately and distinguish systematically between the algorithms derived from them.

	• apply suitable numerical methods to solve technical problems and select and justify the solution strategy depending on the problem. • design algorithms for numerical methods and translate them into a computer programme, resulting in executable and functional code. critically evaluate the results of numerical calculations, particularly with regard to the validity, stability and significance of the numerical solution.
Course content	Definition of simulation technology and numerical methods Iterative methods for solving systems of linear equations Solving non-linear algebraic systems of equations Linear and non-linear optimisation Time integration of ordinary differential equations Discretisation methods for partial differential equations Programming and application of numerical solution strategies Evaluation of numerical results and comparison with the analytical solution using selected examples
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Simulation Methods		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	-
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	Recommended prior knowledge: Numerical methods, basic programming skills		

Other information	Also offered in German in M-CME and M-MB
References	H.R. Schwarz, N. Köckler: Numerical Mathematics, Vieweg and Teubner H. W. Hamacher, K. Klamroth: Linear Optimisation and Network Optimisation, Vieweg

15 Module: W2-d Bionics – Advanced Topics and Applications

Module title	DE	W2-d Bionics – Advanced Topics and Applications			ECTS	5
	EN	…				
Module number						
Module responsibility	Prof. Dr Gaissert					
Lecturers *(optional)*	Prof. Dr Gaissert					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semesters: 1, 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	**Name**	**Frequency**	**Contact (SWS)**	**Self-study**	**ECTS**	**Semester**
Lecture	Bionics: Advanced Topics and Applications	Summer semester only	45 hours (4 contact hours per week)	105 hours	5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • identify, name and classify various application examples from the field of bionics. • to systematically analyse biological models and describe their operating principles in abstract terms. • to independently derive new ideas from natural models and develop innovative bionic concepts.

	• plan a bionic development process in a targeted manner, including the definition of tasks, the analysis phase, concept development and implementation. • to structure and coordinate individual work steps within a bionic development process in a logical manner. • Design and manufacture a functional bionic prototype that reflects the transferred biological principle in its technical implementation. • To methodically apply knowledge from biology to technical problems and critically reflect on the suitability of the transfer approach.
Course content	- Familiarise yourself with the range of bionic models: biomechanics, surfaces, lightweight construction, design, energy efficiency, and more - Creativity techniques - Project plan/project management according to Scrum - Problem identification, problem analysis - Comparison of biological models - Scientific research (literature from biology and engineering, databases) - Formulation of ideas - Technical implementation - Final report (organisation and structure of scientific texts) - Final presentation and defence (structure and organisation of written and oral presentations)
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Bionics – Advanced Topics and Applications Coursework		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Coursework	Duration/Scope	max. 40 pages
Assessment	Graded	Weighting	-
Exam language	☒ German ☐ English	Certificate of attendance	No
Additional information	Group work		
Examination	Bionics – Advanced Topics and Applications Colloquium		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Colloquium	Duration/scope	max. 20 mins
Assessment method	Graded	Weighting	-
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information			

Other information	The submission of the term paper must include a summary of the content in your own words, as well as a defence of the idea and its implementation

References	W. Nachtigall: Bionics: Fundamentals and Examples for Engineers and Scientists, Springer Verlag W. Nachtigall: Bionics as a Science: Recognising→ Abstracting→ Implementing, Springer Verlag B. Hill: Bionics Volumes 1–20, Knabe Verlag Weimar, selection to be agreed with course participants W. Wawers: Bionics: Understanding and Applying Bionic Design

16 Module: W2-e Bio-inspired Engineering

Module title	EN	ECTS	5
	EN W2-e Bio-inspired Engineering		
Module number			
Module Responsibility	Prof. Dr Gaissert		
Lecturers *(optional)*	Prof. Dr Gaissert		
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)		
Stage in the course of study	Standard semesters: 1, 2		
Duration of the module	1 semester		
Language of instruction	☐ German ☒ English		
Contribution to the StG's qualification objectives (optional)	…	Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)

Associated module components

Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Lecture	Bio-inspired Engineering	Winter semester only	45 hours (4 contact hours per week)	105 hours	5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • identify, name and classify various application examples from the field of bionics. • systematically analyse biological models and describe their functional principles in abstract terms. • independently derive new ideas from natural models and develop innovative bionic concepts.

	• plan a bionic development process in a targeted manner, including the definition of objectives, the analysis phase, concept development and implementation. • structure and coordinate individual work steps within a bionic development process in a meaningful way. • Design and manufacture a functional bionic prototype that reflects the transferred biological principle in its technical implementation. To methodically apply knowledge from biology to technical problems and critically reflect on the suitability of the transfer approach.
Course content	- Familiarise yourself with the range of bionic models: biomechanics, surfaces, lightweight construction, design, energy efficiency, and more - Creativity techniques - Project plan/project management according to Scrum - Problem identification, problem analysis - Comparison of biological models - Scientific research (literature from biology and engineering, databases) - Formulation of ideas - Technical implementation - Final report (organisation and structure of scientific texts) - Final presentation and defence (structure and organisation of written and oral presentations)
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Bio-inspired Engineering Term paper		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Coursework	Duration/Scope	max. 40 pages
Assessment method	Graded	Weighting	-
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	Group work		
Examination	Bio-inspired Engineering Colloquium		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Colloquium	Duration/scope	max. 20 mins
Assessment method	Graded	Weighting	-
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information			

Other information	The submission of the term paper must include a summary of the content in your own words, as well as a defence of the idea and its implementation

References	W. Nachtigall: Bionics: Fundamentals and Examples for Engineers and Scientists, Springer Verlag W. Nachtigall: Bionics as a Science: Recognising→ Abstracting→ Implementing, Springer Verlag B. Hill: Bionics Volumes 1–20, Knabe Verlag Weimar, selection to be agreed with course participants W. Wawers: Bionics: Understanding and Applying Bionic Design

17 Module: W3-e Multi-Physics Simulation

Module title	DE	ECTS 5
	EN W3-e Multi-Physics Simulation	
Module number		
Module Responsibility	Prof. Dr Vogel-Brinkmann	
Lecturers *(optional)*	Prof. Dr Vogel-Brinkmann	
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)	
Stage in the course of study	Standard semester: 2	
Duration of the module	1 semester	
Language of instruction	☐ German ☒ English	
Contribution to the StG's qualification objectives (optional)	…	Applicability of the module in other degree programmes

Associated module components						
Teaching method	Name	Frequency	Face-to-face (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	Multi-Physics Simulation	Summer semester only	22.5 hours (2 contact hours)	52.5 hours	2.5	1
Practical	Multi-Physics Simulation	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the module, students will be able to • formulate and solve coupled differential equations numerically using the finite element method (FEM).

- systematically construct and analyse numerical solution methods, including the underlying mathematical and numerical concepts.
- understand and apply the fundamental steps involved in implementing numerical methods in computer systems, and use relevant simulation tools in a targeted manner.
- critically evaluate numerical solution methods in terms of their performance, accuracy and application limits, and compare these with alternative numerical or analytical methods on a sound factual basis.

Course content	This course teaches the fundamental approach to solving coupled field problems using the finite element method. In particular, the mathematical and physical relationships, as well as their finite element formulation, are covered for the following coupled field problems: (1) heat conduction – mechanics; (2) electrostatics – mechanics; (3) magneto-mechanics; (4) an overview of mechanics – acoustics and mechanics – fluid flow. To this end, the relevant partial differential equations are introduced, in particular Maxwell's equations. Finite element technology is extended to higher-order elements, and the challenges involved in solving sparsely populated linear systems of equations are addressed. In the practical session, students independently carry out simulations of practice-relevant coupled field problems.
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Multi-Physics Simulation		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	Recommended prior knowledge: Finite Element Method, basic programming skills		

Other information	…
References	Kaltenbacher, Manfred: Numerical Simulation of Mechatronic Sensors and Actuators – Finite Elements for Computational Multiphysics, Springer

18 Module: W4-e Noise Vibration Harshness

Module title	DE			ECTS	5	
	EN	W4-e Noise, Vibration and Harshness				
Module number						
Module Responsibility	Prof. Dr Biedermann					
Lecturers *(optional)*	Prof. Dr Biedermann					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semesters: 1, 2					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		
Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Lecture	Noise, Vibration and Harshness	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	Noise, Vibration and Harshness	Winter semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	
Compulsory attendance	Compulsory elective module					
Prerequisites for participation						
Learning objectives	Upon successful completion of the course, students will be able to • plan and carry out acoustic measurements independently by selecting and applying suitable signal analysis parameters in a targeted manner.					

- determine acoustic parameters both experimentally and analytically and interpret the results correctly from a technical perspective.
- analyse acoustic and vibroacoustic signals in the time and frequency domains, and systematically identify and isolate characteristic signal components.
- clearly distinguish between sound pressure, sound power and sound intensity, understand their significance in terms of measurement and application, and apply them correctly.
- Critically evaluate manufacturers' specifications regarding acoustic parameters and assess their relevance in the context of application.
- Assess the quality of recorded acoustic and vibroacoustic signals on a sound technical basis, particularly with regard to measurement uncertainties, interference and signal quality.
- Categorise airborne and structure-borne noise sources, analyse possible interactions and evaluate their significance for the overall system.
- Develop low-noise design concepts taking characteristic boundary conditions into account and justify these in accordance with technical principles.

Course content	• Basic concepts of acoustics, noise control and sound design • Psychoacoustic fundamentals (perception of disturbance, roughness, sharpness, timbre) • NVH in the product development process • Buzz, Squeak and Rattle (BSR) testing • Modal analysis/natural frequencies (simulation and measurement) • Simulation of acoustic radiation behaviour based on surface vibrations • Low-noise design of geometries subject to flow/flow acoustics • Transfer path analysis/correlation of airborne and structure-borne sound signals
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Noise, Vibration and Harshness (NVH) course project		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Coursework	Duration/Scope	max. 40 pages
Assessment	Graded	Weighting	
Language of the examination	☐ German ☒ English	Certificate of attendance	No
Additional information	…		
Examination	Noise, Vibration and Harshness Colloquium		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Colloquium	Duration/scope	max. 20 mins
Assessment method	Graded	Weighting	
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	…		

Other information	…
References	G. Müller, G. Möser: Handbook of Technical Acoustics, Springer-Verlag M. Harrison: Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles, Elsevier G. R. Sinambari, M. Fallen: Engineering Acoustics. Vieweg+Teubner U. Karrenberg: Signals, Processes, and Systems, Springer Vieweg K. Genuit: Sound Engineering in the Automotive Sector. Springer-Verlag M. Eigner, D. Roubanov, R. Zafirov: Model-Based Virtual Product Development, Springer Verlag M. Möser: Technical Acoustics, Springer Vieweg U. Lindemann: Handbook of Product Development, Carl Hanser Verlag

19 Module: W5-e Statistics

Module title	DE			ECTS	5	
	EN	W5-e Statistics				
Module number						
Module Responsibility	Prof. Dr Mangold					
Lecturers *(optional)*	Prof. Dr Mangold					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Intelligent & Autonomous Systems (M-IAS)		
Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Lecture	Statistics	Summer semester only	33.75 hours (3 contact hours per week)	52.5 hours	2.5	1
Practical	Statistics	Summer term only	11.25 hours (1 contact hour per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	
Compulsory attendance	Compulsory elective module					
Prerequisites for participation						
Learning objectives	Students will be able to analyse given data sets using appropriate statistical methods and draw well-founded conclusions regarding practical issues.					

	They can formulate relevant events for given or self-defined questions and accurately calculate and interpret their probabilities. They can translate real-world problems into suitable stochastic models, justify their modelling decisions and interpret the results in the context of the original problem. They can estimate statistical parameters using samples, assess the quality of these estimates, and critically reflect on the results in light of the underlying question. select a suitable significance test for a given problem, carry it out correctly, and accurately interpret and communicate the results. model simple stochastic processes using Markov chains, analyse their long-term behaviour, and interpret the results with regard to real-world applications.
Course content	Descriptive statistics - Frequency distributions, histograms, scatter plots - Means, quantiles, sample variance, covariance and correlation - Linear regression Probability theory - Random events, probability measures, conditional probabilities, independence - Discrete and continuous random variables: probability density function, independence, expected value, variance, quantiles - Specific probability distributions, including binomial, Poisson, exponential and normal distributions - Law of large numbers, Central limit theorem - Random vectors: joint and conditional distributions, covariance and correlation Inferential statistics - Parameter estimation: maximum likelihood method, confidence intervals - Significance testing: Type I and Type II errors, binomial test, Gaussian (z) test, t-test, chi-squared tests Bayesian statistics - Prior and posterior distributions - Conjugate distributions and Bayesian models Markov processes - Markov property - Transition probabilities and matrices, Chapman–Kolmogorov equation - Classification of states - Stationary distribution and long-run behaviour
Prerequisite for the award of ECTS	Pass the examination(s)

Examination	Statistics		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☐ German ☒ English	Certificate of attendance	No
Additional information	…		

Other information	…
References	Dobrow, R.: Introduction to Stochastic Processes with R, Wiley

Jacobs, K.: Stochastic Processes for Physicists, Cambridge
Douglas S. Shafer, Zhiyi Zhang: Beginning Statistics

20 Module: W6-d – New metallic materials and systematic material selection

Module title	EN	W6-d – New metallic materials and systematic material selection			ECTS	5
	EN	…				
Module number						
Module responsibility	Prof. Dr.-Ing. von Großmann					
Lecturers *(optional)*	Prof. Dr.-Ing. von Großmann					
Affiliation to the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☐ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar-based teaching	New metallic materials and systematic material selection	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Practical	New metallic materials and systematic material selection	Summer semester only	22.5 hours (2 contact hours per week)	52.5 hours	2.5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module

Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • explain and analyse the high-temperature behaviour of metallic materials and assess its significance for technical applications from a technical perspective. • systematically describe the deformation mechanisms of metallic materials at low and high temperatures, explain their time-dependent behaviour, and apply this to real-world loading scenarios. • assess the creep behaviour of components based on material properties and derive conclusions regarding component safety and fracture behaviour. • Identify new metallic materials for lightweight construction applications, compare their properties, and critically evaluate their potential for use. • Select suitable materials based on a given requirements profile, systematically taking into account mechanical, thermal and other relevant physical properties and providing a technical justification.
Course content	Material behaviour at high temperatures: overview of deformation mechanisms at high temperatures and their temporal behaviour; influencing factors (alloying elements, microstructure formation, technological material pre-treatment) on Mechanical material behaviour: Estimation of component service life using life-cycle diagrams Properties and application examples for various high-performance metallic materials (high-strength steels, aluminium, titanium, nickel alloys, metal matrix composites) Methods of systematic material selection
Requirements for the award of ECTS	Pass the examination(s)

Examination	New metallic materials and systematic material selection Term paper		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Coursework	Duration/Scope	max. 40 pages
Assessment type	Pass/Fail	Weighting	
Examination language	☒ German ☐ English	Certificate of attendance	No
Examination	New metallic materials and systematic material selection Exam		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	…		

Other information	…

References	Bürgel; Maier; Niendorf: Handbook of High-Temperature Materials Engineering, Vieweg-Teubner Verlag Bargel, Schulze: Materials Science, Springer-Verlag Čadek, J.: Creep in Metallic Materials, Elsevier Blum, W.: High-Temperature Deformation and Creep of Crystalline Solids, in Materials Science and Technology, Eds.: R.W. Cahn, P. Haasen, E.J. Kramer, Vol 6: Plastic Deformation and Fracture, Volume Editor: H. Mughrabi, VCH M.F. Ashby: Materials Selection in Mechanical Design, Elsevier

21 Module: W7-d – Product Development in Practice

Module title	DE W7-d – Practical Product Development	ECTS	5
	EN …		
Module number			
Module responsibility	Prof. Dr.-Ing. Monz		
Lecturers *(optional)*	Prof. Dr.-Ing. Monz		
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)		
Stage in the course of study	Standard semester: 2		
Duration of the module	1 semester		
Language of instruction	☒ German ☐ English		
Contribution to the StG's qualification objectives (optional)	…	Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)

Associated module components

Teaching method	Name	Frequency	Contact (contact hours)	Self-study	ECTS	Semester
Seminar	Product Development Practice	Summer semester only	45 hours (4 contact hours per week)	115 hours	5	Whole number
Workload (Workload)	…	…	45 hours (4 contact hours per week)	150 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • systematically analyse and structure complex technical development tasks and break them down into manageable sub-tasks. • to analyse and thoroughly understand a technical and scientific problem within a team, to develop suitable solutions and to implement them collaboratively. • apply knowledge of design, materials, manufacturing and testing techniques in a targeted manner during the development and manufacture of components.

	• Establish connections between operating conditions, material selection, testing, and manufacturing and inspection processes; evaluate these from a technical perspective and incorporate them into the solution-finding process. • Apply methods for assessing the cost-effectiveness of technical solutions and evaluate their impact on product and process decisions. • Structure, document and present work results in a manner appropriate to the audience, both in writing and orally.
Course content	Using a real-world industrial problem, students learn the relationships between the given operating conditions, design and construction, material selection, testing, and manufacturing and inspection procedures. Drawing on their technical and scientific knowledge, students work in a project group to develop a solution concept which is discussed and evaluated in collaboration with industry partners within the framework of project meetings. The result of the project work is presented in a final presentation
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Product Development Practice		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Coursework	Duration/Scope	max. 40 pages
Assessment	Graded	Weighting	
Language of the exam	☒ German ☐ English	Certificate of attendance	No
Additional information	Group work		

Other information	Working on current tasks as a team
References	Ehrlenspiel: Integrated Product Development, Hanser Verlag Dubbel: Mechanical Engineering Pocket Book, Springer

22 Module: W7-e – Product Development Practice

Module title	DE	…			ECTS	5
	EN	W7-e – Product Development Practice				
Module number						
Module Responsibility	Prof. Dr.-Ing. Monz					
Lecturers *(optional)*	Prof. Dr.-Ing. Monz					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☐ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)		

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Seminar	Product Development Practice	Winter semester only	45 hours (4 contact hours per week)	105 hours	5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to • systematically analyse and structure complex technical development tasks and break them down into appropriate work steps. • conduct a thorough analysis of technical and scientific problems within a team, fully understand them, and jointly develop and implement solution strategies. • apply knowledge of design, materials, manufacturing and testing techniques in a targeted manner during the development and manufacture of components.

	• Establish relationships between operating conditions, material selection, testing, and manufacturing and testing processes; evaluate these from a technical perspective and incorporate them into decision-making. • Apply methods for assessing the cost-effectiveness of technical solutions and evaluate their influence on development and design decisions. • Prepare work results in a manner appropriate to the target audience and present them in a structured way, both in writing and orally.
Course content	Using a real-world industrial problem, students learn the relationships between the given operating conditions, design and construction, material selection, testing, and manufacturing and inspection procedures. Drawing on their technical and scientific knowledge, students work in a project group to develop a solution concept which is discussed and evaluated in collaboration with industry partners within the framework of project meetings. The result of the project work is presented in a final presentation
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Product Development Practice		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Term paper	Duration/Scope	Max. 40 pages
Assessment type	Graded	Weighting	
Language of the examination	☐ German ☒ English	Certificate of attendance	No
Additional information	Group work		

Other information	Working on current tasks as a team
References	Ehrlenspiel: Integrated Product Development, Hanser Verlag Dubbel: Mechanical Engineering Pocket Book, Springer

23 Module: W8-d – Advanced Technical Thermodynamics – Hydrogen Technology

Module title	DE	W8-d – Advanced Technical Thermodynamics – Hydrogen Technology	ECTS	5
	EN	…		
Module number				
Module responsibility	Prof. Dr Uhrig			
Lecturers *(optional)*	Prof. Dr Uhrig			
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)			
Stage in the course of study	Standard semesters: 1, 2			
Duration of the module	1 semester			
Language of instruction	☒ German ☐ English			
Contribution to the StG's qualification objectives (optional)	…	Applicability of the module in other degree programmes	Master's in Mechanical Engineering (M-MB)	

Associated module components

Teaching format	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Lecture	Advanced topics in technical thermodynamics – Hydrogen technology	Winter semester only	45 hours (4 contact hours per week)	105 hours	5	1
Workload (Workload)	…	…	45 hours (4 contact hours per week)	105 hours	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the course, students will be able to

- classify hydrogen technologies within the context of a sustainable and resilient energy supply, analyse key opportunities, challenges and conflicting objectives, and evaluate them from a technical perspective.
- provide a structured overview of relevant hydrogen technologies, compare and classify their operating principles, properties and areas of application.
- explain the physical and chemical principles of galvanic cells and apply these to hydrogen-based energy systems.
- to analyse, design and dimension hydrogen systems mathematically, taking into account system-related constraints and causal relationships.
- to analyse dynamic processes in hydrogen systems in depth in order to specifically identify loss mechanisms and ageing processes and evaluate their effects.

Course content	1. Introduction: Is hydrogen a sustainable energy source? 2. Fundamentals a. Hydrogen b. Thermodynamics c. Electrochemistry 3. Energy conversion using hydrogen a. Energy conversion via electrolysis • How it works • Technologies • Design and operation • System architectures b. Energy conversion using fuel cells • How it works • Technologies • Design and operation • System architectures c. Characterisation methods 4. Hydrogen storage and transport a. Compressed, liquid and sorption storage b. Pipelines and mobile transport
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Advanced topics in technical thermodynamics – hydrogen technology		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Written examination / Multiple-choice	Duration/Scope	90 mins
Assessment method	Graded	Weighting	
Examination language	☒ German ☐ English	Certificate of attendance	No
Additional information	…		

Other information	…
References	T. Schmidt: Hydrogen Technology, Hanser J. Töpler et al.: Hydrogen and Fuel Cells, Springer Vieweg

24 Module: W9 – Small-scale project

Module title	DE	W9 – Small-scale project			ECTS	5
	EN	…				
Module number						
Module responsibility	Prof. Dr Boy					
Lecturers *(optional)*	Professors at the MB/VS Faculty					
Assignment to degree programme	E.g.: Bachelor of Applied Chemistry (B-AC)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering M-MB		

Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-degree programme	ECTS	Semester
Project	Small project	in every semester	0	150 hours	5	1
Workload (Workload)	…	…	0	150 h	5	

Compulsory attendance	Compulsory elective module
Prerequisites for participation	
Learning objectives	Upon successful completion of the module, students will be able to • independently analyse and structure complex subject areas and interdisciplinary projects, and prepare them for academic treatment. • identify, research, evaluate and appropriately utilise relevant information in a targeted manner. • systematically analyse incompletely defined problems in mechanical engineering, develop suitable solutions and implement them in a technically sound manner. • familiarise themselves independently and efficiently with new problems, applying suitable methods and tools of academic work in the process.

	• Plan, organise and carry out academic work independently, as well as coordinate complex projects either independently or in a leadership role. • Document work results in a structured manner and present them in a manner appropriate to the audience, both in written and oral form. • Confidently apply and further develop social skills such as teamwork, communication skills and a willingness to cooperate in professional work contexts.
Course content	Structuring and planning the project workflow, breaking the task down into individual work packages to be completed independently, and consolidating the partial results into group work, including documentation and presentation of the results. Students must address a technical problem by applying existing knowledge and skills, incorporating new knowledge and applying the principles of project management.
Prerequisites for the award of ECTS	Pass the examination(s)

Examination	Small-scale project		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Coursework	Duration/scope	max. 40 pages
Assessment	Graded	Weighting	-
Examination language	☒ German ☒ English	Certificate of attendance	No
Additional information	In consultation with the lecturer, the project work may be carried out over two semesters.		

Other information	Registration is handled by the Examination Board.
Further reading	Diethelm: Project Management, Vol. 1 and 2, nwb-Verlag, Herne as well as, depending on the topic of the assignment, as specified by the lecturer

25 Module: W10 – Major Project

Module title	DE	W10 – Major Project			ECTS	10
	EN	…				
Module number						
Module responsibility	Prof. Dr Boy					
Lecturers *(optional)*	Professors at the MB/VS Faculty					
Affiliation with the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering M-MB		
Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Project	Major Project work	in each semester		300 hours	10	1
Workload (Workload)	…	…		300 h	10	
Compulsory attendance	Compulsory elective module					
Prerequisites for participation						
Learning objectives	Upon successful completion of the module, students will be able to • independently analyse and structure complex subject areas and interdisciplinary projects, and prepare them for academic treatment. • identify, research, evaluate and appropriately utilise relevant information in a targeted manner. • systematically analyse incompletely defined problems in mechanical engineering, develop suitable solutions and implement them in a technically sound manner. • familiarise themselves independently and efficiently with new problems, applying suitable methods and tools of academic work.					

- Plan, organise and carry out academic work independently, as well as coordinate complex projects either independently or in a leadership role.
- Document work results in a structured manner and present them in a manner appropriate to the audience, both in written and oral form.

Confidently apply and further develop social skills such as teamwork, communication skills and a willingness to cooperate in professional work contexts.

Course content	Structuring and planning the project workflow, breaking the task down into individual work packages to be completed independently, and consolidating the partial results into group work, including documentation and presentation of the results. Students must address a technical problem by applying existing knowledge and skills, incorporating new knowledge and applying the principles of project management.		
Prerequisites for the award of ECTS	Pass the examination(s)		
Examination	Major project		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Term paper	Duration/scope	max. 80 pages
Assessment	Graded	Weighting	-
Examination language	☒ German ☒ English	Certificate of attendance	No
Additional information	In consultation with the lecturer, the project work may be carried out over two semesters.		
Other information	Registration is handled by the Examination Board.		
Further reading	Diethelm: Project Management, Vol. 1 and 2, nwb-Verlag, Herne as well as, depending on the topic of the assignment, as specified by the lecturer		

26 Module: W11 – Research Project

Module title	DE	W11 – Research Project		ECTS	15	
	EN	…				
Module number						
Module responsibility	Prof. Dr Boy					
Lecturers *(optional)*	Professors at the MB/VS Faculty					
Affiliation with the degree programme	Master's in Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 2					
Duration of the module	1 semester					
Language of instruction	☒ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes	Master's in Mechanical Engineering M-MB		
Associated module components						
Teaching method	Name	Frequency	Contact (SWS)	Self-study	ECTS	Semester
Project	Research project work	in every semester	0	450 hours	15	1
Workload (Workload)	…	…	0	450 h	15	
Compulsory attendance	Compulsory elective module					
Prerequisites for participation						
Learning objectives	Upon successful completion of the module, students will be able to • independently analyse and structure complex subject areas and interdisciplinary projects, and prepare them for academic treatment. • identify the information requirements relevant to the task at hand, select suitable sources, and independently obtain, evaluate and utilise the necessary information. • systematically analyse incompletely defined problems in mechanical engineering, develop solutions and implement them in a technically sound manner. • familiarise themselves with new technical and scientific problems in a targeted and independent manner, applying suitable methods and tools in the process.					

	• Plan, organise and carry out academic work independently, and coordinate complex projects either independently or in a leadership role. • Document work results appropriately and present them in a manner suited to the audience, both in writing and orally. • Apply and further develop social skills such as teamwork, communication skills and a willingness to cooperate in project-oriented work processes.		
Course content	The topic must be submitted by the lecturer to the examination board for approval. Structuring and planning the project workflow, breaking the task down into individual work packages to be completed independently, and consolidating the partial results into group work, including documentation and presentation of the results. A technical problem must be addressed by applying existing knowledge and skills, incorporating new knowledge and applying the principles of project management.		
Prerequisites for the award of ECTS	Pass the examination(s)		
Examination	Research project		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Term paper	Duration/scope	max. 150 pages
Assessment	Graded	Weighting	-
Examination language	☒ German ☒ English	Certificate of attendance	No
Additional information	In consultation with the lecturer, the project work may be carried out over two semesters.		
Other information	Registration is handled by the Examination Board.		
Further reading	Diethelm: Project Management, Vol. 1 and 2, nwb-Verlag, Herne as well as, depending on the topic of the assignment, as specified by the lecturer		

Part 3

Master’s thesis

Master’s thesis

27 Module: M – Master's thesis and Master's seminar

Module title	DE	M – Master's thesis and Master's seminar			ECTS	30
	EN	…				
Module number						
Module responsibility	Prof. Dr Boy					
Lecturers *(optional)*	Primary supervisor					
Affiliation to the degree programme	Master's in Computational Mechanical Engineering (M-CME)					
Stage in the course of study	Standard semester: 3					
Duration of the module	1 semester					
Language of instruction	☒ German ☒ English					
Contribution to the StG's qualification objectives (optional)	…		Applicability of the module in other degree programmes			
Associated module components						
Teaching method	Name	Frequency	Face-to-face (SWS)	Self-study	ECTS	Semester
Thesis	Master's thesis	in every semester	0 hours	840 hours	28	1
Seminar	Master's seminar	in every semester	0 hours	60 hours	2	1
Workload (Workload)	…	…	0 h	900 h	30	
Compulsory attendance	Compulsory module					
Entry requirements						
Learning objectives	The Master's thesis is intended to demonstrate the ability to carry out independent academic work, specifically the independent academic resolution of a problem in the field of computer-aided mechanical engineering. Further learning objectives/outcomes are (depending on the topic): • Ability to identify and obtain the necessary information • The ability to analyse and solve incompletely defined problems in computer-aided mechanical engineering					

- The ability to apply innovative methods when addressing and solving problems in mechanical engineering
- The ability to familiarise oneself with new problems in a targeted manner
- Ability to recognise and explain the non-technical implications of engineering work
- Ability to document and present work results
- Development of social skills (teamwork, communication skills, etc.).

Course content	Independent, academic work, e.g. solving technical and scientific problems, and the development and refinement of technical and organisational systems within the fields of mechanical engineering.		
Requirements for the award of ECTS	Before the final thesis, 30 ECTS credits must have been obtained in the Master's programme, of which at least 10 ECTS credits must be from 'compulsory modules' (P-modules). Submit a StA, pass the examination		
Examination	Master's thesis		
Examination type	☒ Individual examination ☐ Partial examination ☐ Portfolio assessment		
Examination format	Master's thesis	Duration/scope	-
Assessment method	Graded	Weighting	-
Examination language	☒ German ☒ English	Certificate of attendance	No
Additional information	If you register by the end of the first month of the second semester at the latest, the completion period may be extended to 9 months. Otherwise, the completion period must not exceed 6 months.		
Other information	…		
References	Task-specific literature		

Technische Hochschule Nürnberg

For questions regarding ...	Contact
the degree programme itself (study plans, course catalogue, admission criteria, supplementary qualifications , module handbook)	**Programme Director** Prof. Dr Felix Boy **Programme administration** Prof. Dr Felix Boy
Applications to the Examination Board of the programme	**Chair of the Examination Board** Prof. Dr Felix Boy
Programme Administration (e.g. examination and placement matters, re-registration, recording of marks)	**University Student Office** studienbuero-technik@th-nuernberg.de

As of April 2026

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