Module manual for
Management and Engineering in Computer Aided Mechanical Engineering
MSMMECAME

SPO Version 2020
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RWTH AACHEN UNIVERSITY

Module manual for Management and Engineering in Computer Aided Mechanical Engineering (Master (1-Subject))

Module manual for
Management and Engineering in Computer Aided Mechanical Engineering
MSMMECAME

RWTH AACHEN UNIVERSITY

Examination Regulation Field

Module offer

Examination offer

Teaching offer

CONTENT
Module manual for
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Examination Regulation Title & Version:
Management and Engineering in Computer Aided Mechanical Engineering (SPO Version / 2020)

Title	Management and Engineering in Computer Aided Mechanical Engineering
Short title	MSMMECAME
Version	2020
Study/Qualification Objectives	The master's degree program in Management and Engineering in Computer Aided Mechanical Engineering (MME-CAME) qualifies graduates in the areas of computer-aided modeling and simulation technology, computer-aided design of individual parts, assemblies and computer-aided production in mechanical engineering, design of manufacturing processes, life cycle prediction of materials, parts, and components. Graduates who have obtained this master's degree have the following qualifications: • They have acquired in-depth knowledge in the application of computer-aided design software for the design and generation of complex engineering solutions for design tasks in the field of mechanical engineering. • Graduates are capable of taking on management tasks responsibly and independently. • They possess communication skills and understand the technical, business, and cultural challenges and areas of tension in an international context. They are able to design and implement projects in a solution-oriented and target-oriented manner. • They are critically aware of the tasks at the interface between engineering and economics and have the knowledge and skills to recognize new developments and technologies at an early stage and to evaluate their significance for the respective field of activity.
Qualification Profile	
Additionnal information	

+ Advanced Control Systems (6010486)

Module titel	Advanced Control Systems (Compulsory subject)
Identifier	6010486
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2010
Valid until	-
Module level	Master
Content	• Fundamentals of multivariable systems and representation • Analysis of multivariable systems, modelling of uncertainties • General control configuration, performance and robustness • H2- (LQR/LQG) control • Introduction to robust H∞;-control • Implementation aspects of robust controllers ; • µ;-Synthesis
Learning Objectives/ Learning Outcomes	Students develop an advanced understanding of multivariable system analysis and apply modern robust control techniques. This includes the application of modern multivariable analysis and control tools for complex processes in order to design feedback controllers for processes with uncertainties and multiple and opposed design goals. Students understand and apply state-space, as well as frequency domains methods, for multivariable systems.
(Study-Specific) Prerequisites	-
(recommended) Requirements	Systemtheorie 1 &; 2 or similar control systems lecture course covering classical control and state-space techniques.
References	• Skogestad und I. Postlethwaite, Multivariable Feedback Control, Wiley, 2005 • Morari und E. Zafiriou, Robust Process Control, Prentice-Hall International, 1989 • A. Francis, A Course in Hinf-Control Theory, Springer-Verlag, Berlin, 1987 • A. Hyde, Hinf-Aerospace Control Design, Prentice-Hall International, 1989
Language	English
Examination Terms	Course work (30%) and oral examination (70%). The final grade is calculated from coursework and oral examination achievement. Modalities of the examination will be discussed with students at the first lecture.
Miscellaneous	-
Module coordinator	RWTHModulverantworlicher: Universitätsprofessor Dr. med. Dr.-Ing. Klaus Steffen Leonhardt Dr.-Ing. Berno Misgeld
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	30
Total hours (h)	120,0

+ Advanced Control Systems (6010486)

Contact hours (h)	45,0
Self-study hours (h)	75,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Advanced Control Systems (601048601)	1st semester	no semester recommended	4	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise Advanced Control Systems	1st semester	no semester recommended	-	3

+ Management and Engineering Perspectives (4022679)

Module titel	Management and Engineering Perspectives (Compulsory subject)
Identifier	4022679
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2020
Valid until	-
Module level	Master
Content	Management and Engineering Perspectives Rapid technical progress requires sophisticated and scientifically sound management strategies. Business decisions must be made on the basis of solid technical expertise as well as on a business model focused, risk assessing mindset. This is where the module is focused in. The structure and content of the module demonstrate the close interweaving of engineering and management (economic) perspectives and how it can be used for the successful market introduction of technologies. The module offers an interdisciplinary view on decision making processes under uncertainty that ventures face in practice every day. In particular management tools and methodologies are used to evaluate technology driven corporate / start-up undertakings. The goal is to build an understanding and awareness for the both different worlds of management and engineering and thereby enable the student to effectively act as bridge builders between these two worlds. The topics covered and deepened via case studies include: strategy and entrepreneurship, quality and product management, modelling and simulation, software application areas, knowledge and project management, logistics, as well as financial evaluation of technology driven topics
Learning Objectives/ Learning Outcomes	Knowledge / Understanding Students • understand the complex sides and different approaches of both management and engineering parties involved in decision making under uncertainty ; ; • recognize the importance of team work and outward constraints when tackling a practical problem • know the pros and cons of engineering and a management mindsets and decision making processes • become aware of the value of interdisciplinary approaches to find solutions for multifaceted challenges Abilities / Skills Students • apply this knowledge to elaborate possibilities for an interdisciplinary approach to complex issues • derive numbers and figures from cases &; company examples • conceptualize both the product and the business model • analyse problems in all enterprise domains which are involved in management and/or engineering processes of a company

+ Management and Engineering Perspectives (4022679)

	• apply different methodologies along the entire development process Competencies Students • take responsibility for basic management tasks • effectively communicate with representatives from both management and technology • integrate both the management and the engineering mindset for successful management decision making • integrate both the product and the business model focus for a successful market launch • present and communicate results of their teamwork • use interdisciplinary and connected concepts in practice • critically reflect upon the consequences of both engineering and managerial decision making behaviour
(Study-Specific) Prerequisites	-
(recommended) Requirements	none
References	-
Language	English
Examination Terms	written and oral exam
Miscellaneous	-
Module coordinator	Prof. Dr. rer. pol. Malte Brettel
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Management and Engineering Perspectives (402267901)	1st semester	no semester recommended	5	-

+ Management and Engineering Perspectives (4022679)

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture/Exercise Management and Engineering Perspectives	1st semester	no semester recommended	-	4

+ Quality Management (4011453)

Module titel	Quality Management (Compulsory subject)
Identifier	4011453
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	The digitalization and networking of production increases the availability of data over the entire product life cycle and changes the role of quality management in relation to systems, processes and products. With the shift in focus of data analysis from reactive and corrective to proactive and predictive, the principles of quality management remain, but actors acting in quality management need new tools, e.g. from the domain of machine learning, to deal with increased complexity. The lecture deals with the interweaving of quality-related methods with the needs of a rapid situation clarification of possibly deviating processes along value chains or the associated industrial services. The orientation towards the structure of the "Internet of Production" first builds on the principles of quality management (e.g. important standards, clarification of the terms system, process and product quality). The identification of quality relevant data sources (incl. social media) along the product life cycle leads to the modelling of the data-information-knowledge pyramid. The statistical/stochastic basics serve as a fundamental basis to understand methods of data analytics and machine learning and are applied situationally to typical problem classes from different areas of quality management (e.g. process control, risk management, fault management), which are typified with regard to their structure and thus made accessible for rationalization. The goal is to increase the action competence of actors by decision support (e.g. by the use of smart devices). Contributions from practice give insight into the implementation of quality management in industry.
Learning Objectives/ Learning Outcomes	Knowledge Students shall know • Important standards and guidelines in the knowledge domain "quality management" • structure of standards (high-level structure) • System, process and product quality • Quality relevant data and data sources along the product life cycle • Statistical and methodical basics of "Industrial Intelligence" as a core task of QM • Legal implications Understanding Students shall understand • The "Internet of Production" • The importance of quality and machine learning methods in networked adaptive production • Importance of quality and quality management in networked, adaptive production • The Classification of typical problems • basic data analytics and machine learning methods Students shall be able to apply: • Data collection (e.g. customer insights in the product development process and during product usage, data-driven procurement management) • selected data analytics and machine learning methods (e.g. for risk quantification and prediction, process control) • Quality management for services • Decision support of the "Smart Quality Expert" (e.g. predictive quality, predictive maintenance) Skills and Competencies

+ Quality Management (4011453)

	Students • shall develop an understanding of the different forms of the quality concept that can be operationalized in the operational process and classify them in the sense of "Industrial Intelligence". • shall be able to identify and classify problems in the corporate context. • shall have basic knowledge in the field of machine learning, shall know corresponding advanced quality management methods and be able to describe their specific applicability and effectiveness. • shall be able to theoretically and practically penetrate applications in the quality management domain with the knowledge imparted to them as a 'tool'. • shall be able to build up the structure of an "Industrial Intelllgence" by means of quality management methods in the corporate context, to evaluate it with regard to its effectiveness and to further develop and meaningfully link quality management methods based on an understanding of interrelationships and principles. • shall be able to intervene in value chains in an improving way based on their well-founded methodological and organizational knowledge. • shall be able to recognize and evaluate situations, strengths and weaknesses of an existing quality management system and to formulate suitable measures for a coherent further development. The contents are based on research of the Cluster of Excellence "Internet of Production". Considering this background, the participants should take the mental transformation from the application of tools (methodological competence) to the design of the underlying principles and cause-effect relationships in value chains (action competence).
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	• Lecture Notes • Students also receive a list of relevant literature
Language	English
Examination Terms	Written (100 %)
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Robert Schmitt
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

+ Quality Management (4011453)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Quality Managment (401145301)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture/Tutorial Quality Management	1st semester	no semester recommended	-	4

+ Computational Intelligence in Engineering (4021493)

Module titel	Computational Intelligence in Engineering (Compulsory subject)
Identifier	4021493
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	The elective course “Computational Intelligence in Engineering“ is available for students enrolled in the engineering Master programs of RWTH Aachen University. It provides an overview over recent applications of computational intelligence and deep learning that are relevant to engineering. The first half of the course content is a theoretical introduction into the topic of machine learning in engineering and programming fundamentals in Python. In the second half of the course, the students apply their gained knowledge in project-based learning. The course will be taught interactively, engaging the students using practical example projects. The following topics are covered: • Time-variant dynamic processes from simulations or experiments • Data acquisition and pre-processing • Machine learning algorithms and neural network models • Advanced neural networks architectures • Project-specific engineering problems • Programming fundamentals in Python for data-driven procedures
Learning Objectives/ Learning Outcomes	The course curriculum consists of interactive seminar lectures accompanied by semester project works. During the seminar lectures, the students will receive the necessary theoretical information and supervision to independently plan, advance and complete the projects in small groups. In addition, the seminars offer the opportunity to discuss challenges and problems arising during projects. Finally, the achievements and results obtained within the student projects will be presented by the students in the scope of the seminar lectures and the accompanying computer lab exercises. <u>Knowledge / Understanding</u> The students will understand • current trends in computational intelligence and their theoretical foundation in the context of engineering applications • the advantages of machine learning algorithms in engineering but also the limits of the methods and when better not to use them <u>Abilities / Skills:</u> The students will be able to • apply machine learning methods to a wide variety of engineering Problems • transfer their knowledge to new engineering applications in science and industry via the practical expertise gained • evaluate the merits and limitations of machine learning methods applied to computer aided engineering problems
(Study-Specific) Prerequisites	-
(recommended) Requirements	Programming experience is advantageous, preferably the language Python.

+ Computational Intelligence in Engineering (4021493)

References	• Goodfellow, I., Bengio, Y., Courville, A., 2016. Deep Learning. MIT Press. • Keller, J.M., Liu, D., Fogel, D.B. , 2016. Fundamentals of Computational Intelligence. IEEE Press, Wiley.
Language	English
Examination Terms	Written Examination or Oral Examination (100 %)
Miscellaneous	-
Module coordinator	Univ.-Prof. Dr.-Ing. Bernd Markert
ECTS Credits	5
Contact time (WSH)	3
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	45,0
Self-study hours (h)	105,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Computational Intelligence in Engineering (402149301)	1st semester	no semester recommended	5	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture "Computational Intelligence in Engineering	1st semester	no semester recommended	-	2
Exercise Computational Intelligence in Engineering	1st semester	no semester recommended	-	1

RWTH AACHEN UNIVERSITY

– Modelling and Simulation Engineering
– Compulsory Courses
+ Failure of Structures and Structural Elements (4011486)

Module titel	Failure of Structures and Structural Elements (Compulsory subject)
Identifier	4011486
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2011
Valid until	-
Module level	Master
Content	The course is an introduction into the most important failure theories of structures. The content is summarized as: • Recall of fundamentals in continuum mechanics • Notion of “failure” in mechanical engineering. • Geometry and deformation: strain tensors • Mechanical and thermal loading: stress tensors • Conservation laws • Material behaviour: elasticity, elasto-plasticity, hardening, damage • Anisotropy • Yield-conditions and flow rules in plasticity and visco-plasticity • Direct methods: Lower and upper bound theorems of limit analysis • Examples of application of the theorems of limit analysis • Direct methods: Lower and upper bound theorems of shakedown analysis • Examples of application of shakedown theory • Notion and concepts of fracture mechanics • Linear elastic fracture mechanics • Elastic-plastic fracture mechanics • J-integral and other path-independent integrals • Kinematic criteria • Examples of application of fracture mechanics • Use of finite element methods • Software features, examples

Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following:
	
	<u>Knowledge / Understanding:</u>
	The students will understand:
	• the physical effects leading to failure of structures and mechanical systems. This includes:
	  • excessive elastic deformations,
	  • buckling of load carrying elements,
	  • permanent plastic deformations,
	  • material damage,
	  • initiation and propagation of cracks
	• limit and shakedown theories, failure of structures and mechanical systems under monotonic and cyclic loads and determination of corresponding load-carrying capacities
	• the phenomenon of fracture and determination of critical loads for crack propagation
	• the most important failure types and their numerical description
	
	<u>Abilities / Skills:</u>
	The students will be able to
	• a) determine limit loads for structures
	• b) model the phenomenon of fracture and determine critical loads for crack propagation

	• c) transfer theoretical and mathematical models to actual engineering problems and implementation into design codes • d) apply State-of-the-art numerical methods for the use of failure criteria in applied mechanical engineering The exercises are integrated in the lecture so that the students work individually or in groups on practical examples.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	• Lecture Notes • J. Lemaitre, J.-L. Chaboche: Mechanics of materials, Cambridge University Press, Cambridge, 1994 • J.A. König: Shakedown of elastic-plastic structures, Elsevier, Amsterdam, 1987
Language	English
Examination Terms	Written Examination
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Bernd Markert
ECTS Credits	5
Contact time (WSH)	2
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	30,0
Self-study hours (h)	120,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Failure of Structures and Structural Elements (401148601)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Failure of Structures and Structural Elements	2nd semester	no semester recommended	-	2

– Modelling and Simulation Engineering
– Compulsory Courses
+ Nonlinear Structural Mechanics (4012290)

Module titel	Nonlinear Structural Mechanics (Compulsory subject)
Identifier	4012290
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2010
Valid until	-
Module level	Master
Content	• Introduction and motivation: • Brief review of FE discretisation (solid vs. shell elements) • Brief review of linear statics and dynamics of structures • Structural nonlinearity: stress stiffening/softening, buckling, effect on nonlinear vibrations • Review of classical kinematical hypotheses (Bernoulli / Kirchhoff-Love), shortcomings, necessity of refined hypotheses • Index notation, Einstein summation convention • Kronecker symbol and associated rules • Scalar and vector product, matrix multiplication in index notation • Convected coordinates, parameter lines for a 3-D body • Co- and contravariant base vectors • Examples: cylindrical and spherical geometry • Co- and contravaiant metric tensor components • Co- and contravariant vector and tensor components • Vector product of base vectors, permutation tensor, metric tensor determinant • Surface parameter lines • Co- and contravariant surface base vectors, normal vector • Surface metric and permutation tensor • Equations of Gauss and Weingarten • Christoffel symbols • Curvature tensor of a surface • Geometrical considerations (length, area and volume elements) in the shell space, at the reference surface, at the bounding surfaces, and at the lateral boundary • Deformed configuration • Base vectors of the deformed configuration • Covariant derivative • Shifter tensor, mean and Gaussian curvature • Principle of virtual displacements • Internal and external virtual work • Definition of stresses and strains • Strain tensor for von Kármán-type nonlinearity • Strain-displacement relations for tangential, transverse shear and transverse normal strains • First-order shear deformation hypothesis • Interpretation of the kinematical variables, rotations at the reference surface • Outlook: Refined hypotheses • Nonlinear strain-displacement relations for first-order shear deformation (Reissner-Mindlin) plate and shell theory • Transition to Kirchhoff-Love plate and shell theory / Bernoulli beam theory • Internal virtual work • Internal stress resultants • Theorem of Gauss • External virtual work (surface tractions, body forces, inertia forces) • Surface load couples, boundary load couples • Body couples, inertia couples • Nonlinear equilibrium equations • Static boundary conditions

– Modelling and Simulation Engineering
– Compulsory Courses
+ Nonlinear Structural Mechanics (4012290)

Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following: Knowledge / Understanding: Students • shall know the important steps and features of consistent modeling of 2-D and 1-D structures for linear and nonlinear static and dynamic analysis. • shall be able to understand structural theories (e.g. in commercial FE-codes, in scientific publications etc.), to classify them, and to estimate the consequences of underlying hypotheses for the quality of obtainable simulation results. Abilities / Skills: Students • shall be able to analyse static and dynamic simulation results with respect to the quality of the adopted structural model. • are expected to transfer theoretical models to actual engineering problems of statically or dynamically loaded beam, plate and shell structures (e.g. arbitrary geometries, arbitrary boundary conditions, arbitrary material and ply lay-up). Competencies: Students • shall be able to critically assess the applicability, consistency and correctness of structural models. • shall be able to use their obtained knowledge in order to
(Study-Specific) Prerequisites	-
(recommended) Requirements	recommended: • Basic knowledge in mechanics (statics, strength of materials, dynamics)
References	A. H. Nayfeh, P. F. Pai: Linear and Nonlinear Structural Mechanics, Wiley-Interscience, 2004
Language	English
Examination Terms	Written exam
Miscellaneous	-
Module coordinator	apl. Prof. Dr.-Ing. Marcus Stoffel
ECTS Credits	5
Contact time (WSH)	3
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	45,0
Self-study hours (h)	105,0

− Modelling and Simulation Engineering
− Compulsory Courses
+ Nonlinear Structural Mechanics (4012290)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Nonlinear Structural Mechanics (401229001)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Vorlesung Nonlinear Structural Mechanics	2nd semester	no semester recommended	-	2
Übung Nonlinear Structural Mechanics	2nd semester	no semester recommended	-	1

– Modelling and Simulation Engineering
– Compulsory Courses
+ Continuum Mechanics (4013360)

Module titel	Continuum Mechanics (Compulsory subject)
Identifier	4013360
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2010
Valid until	-
Module level	Master
Content	• Material bodies, configuration, coordinates • Rigid body motion • Deformation gradient • Deformation of surface and volume elements • Strain, stretch and shear • Spectral decomposition of strain tensors • Strain invariants • Polar decomposition of the deformation gradient, stretch tensors • Strain measures • Velocity gradient • Cauchy stress tensor • Linear momentum balance • Scalar form of the linear momentum balance • Rotational momentum balance • Balance of mechanical energy • Work-conjugate stress-strain pairs • General principles of the constitutive theory, Noll axioms • Change of frame, objectivity • General constitutive relation, simple materials • Elastic materials • Material symmetry, isotropic materials • Hyperelastic materials • Mock-Examination
Learning Objectives/ Learning Outcomes	During the course, the students will obtain knowledge of the principles of continuum mechanics and exercise the subject matter by considering realistic problems. In particular, attending students will • learn how to describe the state of strain and stress in a material body that undergoes large elastic deformations • calculate the usual strain and stress tensors • understand and apply the principle of balance equations • understand the principles of the constitutive theory • learn to apply material laws • be able to read scientific literature on continuum mechanics. Throughout the course, the students will use and practice the nowadays usual absolute notation for tensors. Furthermore, examples based on Cartesian and curvilinear coordinates will be considered.
(Study-Specific) Prerequisites	-
(recommended) Requirements	recommended: • Module Tensor Algebra and Tensor Analysis for Engineers I
References	• Ogden, R.W. Non-linear Elastic Deformations, Ellis Harwood Ltd. (1984)

	• Basar, Y., Weichert D. Nonlinear Continuum Mechanics of Solids, Springer (2000)
Language	English
Examination Terms	Written exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. (RUS) Mikhail Itskov
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Continuum Mechanics (401336001)	2nd semester	no semester recommended	5	0
Exercise Continuum Mechanics (401336002)	2nd semester	no semester recommended	0	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Continuum Mechanics	2nd semester	no semester recommended	-	2

– Modelling and Simulation Engineering
– Compulsory Courses
+ Intelligent Monitoring of Engineering Systems (4021494)

Module titel	Intelligent Monitoring of Engineering Systems (Compulsory subject)
Identifier	4021494
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	The course curriculum consists of seminar lectures followed by a semester project. During the seminar lectures, the students will receive the necessary theoretical background to independently plan and execute the project in small groups. Consultation hours are offered to discuss challenges and problems arising during the course of the project. Finally, each group presents their achievements and results live and in form of a written report. The following topics are covered: • Sensing • Signal processing • Machine learning • Non-Destructive Testing (NDT) • Structural Health Monitoring (SHM) • Data pre- and postprocessing using MATLAB
Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following: Knowledge / Understanding The students will understand • the theoretical foundations of structural health monitoring approaches in engineering • state-of-the-art and current trends in structural health monitoring • the fundamentals of sensors, filtering methods, and computational Intelligence Abilities / Skills The students are able to • describe and analyse mechanical engineering systems • extract and monitor relevant system parameters • apply fundamental methods of structural health monitoring • transfer their knowledge to new engineering applications in science and industry • independently plan, advance and complete projects
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: Programming experience, particularly in MATLAB (Python)
References	Farrar, C.R. and Worden, K., 2012. Structural Health Monitoring: A Machine Learning Perspective. Wiley.
Language	English
Examination Terms	Written or Oral Examination (100 %)

– Modelling and Simulation Engineering
– Compulsory Courses
+ Intelligent Monitoring of Engineering Systems (4021494)

Miscellaneous	-
Module coordinator	Univ.-Prof. Dr.-Ing. Bernd Markert
ECTS Credits	5
Contact time (WSH)	3
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	45,0
Self-study hours (h)	105,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Intelligent Monitoring of Engineering Sys-tems (402149401)	2nd semester	no semester recommended	5	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Intelligent Monitoring of Engineering Systems	2nd semester	no semester recommended	-	2
Exercise Intelligent Monitoring of Engineering Systems	2nd semester	no semester recommended	-	1

Module titel	Advanced Finite Element Methods for Engineers (Compulsory elective subject)
Identifier	4013866
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	Content • General introduction, concept of the finite element method • Symbolic assembly procedure • Global and local coordinates • Stiffness matrix for trusses / coordinate transformation • Variational techniques • Solution of truss structures • Variational techniques, Euler-Lagrange equation • Natural and forced boundary conditions • Multiple integrals, Gauss-Theorem • Variations of elementary algebraic functions • Variational principle for linear self-adjoint diff. operators • Solution of some classical variational problems • Principle of virtual work as a weak form of the momentum balance, variational principles of mechanics (Lagrange, Hu-Washizu) • Differential equation of a linear elastic bar, analytic solution for various load cases • Rayleigh-Ritz method, weighted residual approximations, Point or subdomain collocation • Galerkin method, least-squares method, linear elastic bar approximated by a continuous shape function • Displacement formulation • Three-field (mixed) formulation • Examples to weighted residual approximations • Requirements to shape functions • Continuous shape functions, piecewise defined shape functions, approximation by piecewise defined shape functions. • 2-d problems of elasticity, triangular element, plain strain and plane stress problems, • Torsion of a prismatical bar • Examples for plain strain and plane stress problems discretized by linear triangular elements

	• Axisymmetric stress analysis, 3-d stress analysis • Construction of 2-d and 3-d finite elements (Lagrange and serendipity family) • Concept of hierarchical shape functions • Concept of mapping in iso-parametric finite elements • Application of numerical integration in 1-d, 2-d and 3-d finite element problems • Non-linear finite element problems (Newton-Raphson method) • Dynamic (time-dependent) finite element problems, time step size and mass scaling
Learning Objectives/ Learning Outcomes	The aim of the course is to impart the basic knowledge about finite element methods and their application to solid and structural mechanics. The students will • understand why the FE-Method and the other numerical methods behind are important for engineering practice • understand the basic concept of FEM • be able to find solutions for trusses with a variety of boundary conditions • understand the fundamental concept of variational calculus • be able to find solutions for mechanical problems by using weighted residual methods • be able to use finite element method for plane strain, plane stress and torsion problems • be able to construct finite elements with linear and non-linear shape functions • understand the application of numerical integration in finite element method • understand the concept of non-linear and time-dependent finite element problems In addition, voluntary programming exercise sessions are offered to deepen the theoretical understanding. A simple FEM solver is developed in Python, numerical integration schemes are discussed and the FEniCS programming package is introduced.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-
References	-
Language	English
Examination Terms	Written exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. (RUS) Mikhail Itskov
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0

Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Advanced Finite Element Methods for Engineers (401386601)	1st semester	no semester recommended	5	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Finite Element Methods for Engineers	1st semester	no semester recommended	-	2
Tutorial Advanced Finite Element Methods for Engineers	1st semester	no semester recommended	-	2

Module titel	Advanced Software Engineering (Compulsory elective subject)
Identifier	4011468
Version	V3
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	The aim of the course is to explain students for what purposes, under which conditions and with which consequences computer systems are used for the solution of problems related to Mechanical Engineering.Within the first part of the course the steps from problem description to the final software solution are illustrated. This covers the topics modelling, problem elicitation and analysis, program design and an introduction to UML (Unified Modelling Language) and implementation in C++ Java. Then the course goes on with a closer examination of the various aspects which comprise software development, concerning topics like design patterns, agile software processes and project management. Parallel to the lecture the students are given the chance to employ the theoretical input from the course in small software projects. After an introduction to Java and object-oriented programming, the students stepwise pass through the particular stages of a software development process.
Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following: Knowledge / Understanding: Students • are to gain solid knowledge in the Software Development Life Cycle and also the main activities and core concepts in different software development phases. Abilities / Skills: Students • shall have the ability to transfer the acquired knowledge in object - oriented design to different engineering problems and understand the general structure and the functionality of software.
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: • Basic knowledge in a programming language (e.g. C, C++, Java, Python)
References	• Bruegge, B.; Dutoit, A. (2009): Object-Oriented Software Engineering • Using UML, Patterns and Java. Boston: Pearson. • Sommerville, I. (2010): Software engineering. Boston: Pearson
Language	English
Examination Terms	Written or oral Examination (100 %)
Miscellaneous	-
Module coordinator	Dipl.-Inform Daniel Lütticke

– Modelling and Simulation Engineering
– Compulsory Courses
– Advanced Finite Element Methods or ...
+ Advanced Software Engineering (4011468)

ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Advanced Software Engineering (401146801)	3rd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Software Engineering	3rd semester	no semester recommended	-	2
Tutorial Advanced Software Engineering	3rd semester	no semester recommended	-	2

Module titel	Modeling, Model Reduction and Simulation in Laser Processing - Applications (Compulsory elective subject)
Identifier	4013864
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2016
Valid until	-
Module level	Master

Content	• overview of contents, definition of the learning targets
	• ecapitulation of the 10 learning targets from part I of the course
	• derivation and consolidation of the application of integral methods for treating heat conduction with Stefan-type boundary conditions
	• Learning target 1: variational formulation compared with direct integration for one space variable, spectral methods for error control of integral methods: spatial one-dimensional model problem, Eigenfunctions of differential operators, spectral decomposition of non-linear problems, discrete and continuous spectra
	• Learning target 2: separation of variables and relation to spectral methods, applications of spectral methods, asymptotic expansion of partial differential equations and their solution applied to a model problem of heat conduction
	• Learning target 3: identification of characteristic dynamical variables, degrees of freedom of an inertial manifold, determination of dimensionless groups, Buckingham's Pi-theorem, definition and physical meaning of Peclet-, Reynolds-, Marangoni- and Stefannumber.
	• Learning target 4: physical interpretation of dimensionless groups of system parameters and the dimension in phase space of processing parameters, optical modes in passive fibers, numerical aperture, total reflection, maximum mode-number, coupling of modes, optical excitation in active fibers and dissipation
	• Learning target 5: Slow surfaces in dynamical systems, Application of time scale separation
	• Learning target 6: thermal effects of large and small Peclet-number, model problems in thin film flow, applications of spectral methods:
	  • formation of pores in welding, closure of the drill hole
	• Learning target 7: relation of time scales and the onset of quality features, modelling evaporation and recondensation of metals I, comparison of models from Aden and Aoki &; Sone
	• Learning target 8: liquid-vapor phase transition in drilling and welding, modelling evaporation and recondensation of metals, Laplacepressure, evaporation and recondensation as driving forces for momentum of the liquid by pressure gradients
	• Learning target 9: boundary conditions for momentum at ideal surfaces,
	• technical examples:
	  • drilling with laser radiation, welding with laser radiation, concluding discussion of learning targets
	• actual research and development of laser processing

Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following: <u>Knowledge / Understanding:</u> Students shall obtain understanding about the applications of: 1. Free Boundary Problems and integral methods of solution, 2. analysis of dynamical stability, non-linear stability analysis using spectral methods, 3. analysis of the structural stability of model equations. <u>Abilities / Skills:</u> Students

	• shall obtain scientific skills for the application of free Boundary Problems and integral methods of solution, non-linear stability analysis using spectral methods and for the analysis of the structural stability of model equations. • shall be able to determine the maximum number of dimensionsless groups of Boundary Value Problems. • shall understand the relation of boundary conditions, boundary values and the structure of solution for the Navier-Stokes equations. • shall know and understand the 5 different, dominant phenomena of drilling, welding and cutting with laser radiation. • shall know and be able to explain the physical meaning of the Navier-Stokes equations. • shall know the main properties of the solution in the asymptotic case of thin film flow (boundary layer) and shall be able to explain the relation between dynamical properties of the solution and quality features of the product as well as productivity of the process for drilling and cutting. • shall know the effect of dissipation in distributed dynamical systems (inertial manifold) and shall know examples for the application of methods for the reduction of the dimension in dissipative systems. • shall understand and perform the separation of length and time scales in simple systems. • shall understand the interactive cooperation of scientists from engineering, physics and mathematics for application of model based methods for diagnosis in laser processing.
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: • Modeling, Model Reduction and Simulation in Laser Processing - Laser
References	• Lecture Notes • Students also receive a list of relevant literature
Language	English
Examination Terms	Oral exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Constatntin Leon Häfner
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Modeling, Model Reduction and Simulation in Laser	1st semester	no semester recommended	5	0

Processing - Applications (401386401)				

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Modeling, Model Reduction and Simulation in Laser Processing - Applications	1st semester	no semester recommended	-	2
Lecture Modeling, Model Reduction and Simulation in Laser Processing - Applications	1st semester	no semester recommended	-	2

– Modelling and Simulation Engineering
– Elective Courses
+ Machine Tools (4011460)

Module titel	Machine Tools (Compulsory elective subject)
Identifier	4011460
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2013
Valid until	-
Module level	Master
Content	1 • L: An introduction to the machine tool design and machine tools for forming • E: Metal-forming machines 2 • L: Metal-cutting maschines with geometrically defined and undefined cutting edges • E: Tour around the shop floor of WZL and IPT 3 • L: Design of mounts and mount components with respect to the static behavior • E: Design of structural components and software tools for the design of machine tools 4 • L: FEM, Multi-Body-Simulation, Machine Foundations • E: Finite-Element-Analysis 5 • L/E: Hydrodynamic and hydrostatic guideways and bearings 6 • L: Ball screws, spindle bearing systems, seals and covers • E: Bearing, spindle bearing systems 7 • L: Structure of feed drives, mechanical components of feed drives, position measuring systems and control systems • E: Layout of the mechanical components of feed drives 8 • L/E: Inverters and Drives 9 • L/E: Measuring instruments, geometric and kinematic behavior of machine tools 10 • L/E: Static, kinematic and thermal behavior of machine tools, Introduction tot he dynamics 11 • L/E: Metrological analysis of the dynamic behavior of machine tools 12 • L: Acoustic behavior of machine tools • E: Principles of noise measurement and rating 13 • L/E: Exam preparation
Learning Objectives/ Learning Outcomes	Subject-related: his course will provide participants with advanced knowledge about the most important machine types as well as their application fileds and the associated machine components. After the course students will know the basic characteristics of the machines and their components as well as their function. Thus they are able to distinguish typical machine tools and describe their functions. In addition, students will be able to explain the basic tasks and functions of machine programming and control as well as the drive control. Not subject-related: he students can derive the properties of the machines and their components theoretically or analytically/numerically and derive the necessary design variables. In this way, they are able to examine the importance of the individual components with respect to the whole machine

	system. Furthermore, the students are able to transfer their knowledge of the programming, control and drive control of machines to specific applications. The students are able to assess the suitability of machine tools in relation to a given requirement profile.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-
References	Skripte lecture and exercise for download as PDF
Language	English
Examination Terms	Written exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Brecher
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Machine Tools (401146001)	1st semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Machine Tools	1st semester	no semester recommended	-	2
Lecture Machine Tools	1st semester	no semester recommended	-	2

Module titel	Mechatronics and Control Techniques for Production Plants (Compulsory elective subject)
Identifier	4011451
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2013
Valid until	-
Module level	Master

Content	• Indroduction of Mechatronics and Control Techniques for Production Plants
	• Mechanical controls
	  • Machine elements of mechanical controls
	  • Application examples for mechanical controls
	• Information processing in mechatronic systems
	  • Theory and examples of embedded systems
	  • Programming of embedded systems and logical controls
	• Programmable Logic Control (PLC) and Motion Control (MC)
	  • Programming of programmable logic controllers
	  • Test methods of programmable logic controllers (HIL)
	• Numerical Control 1: Design, programming, CAM
	  • NC programming procedures (manual and workshop-oriented)
	  • NC programming of CAM systems
	• Numerical Control 2: Interpolation
	  • Structure of an NC control
	  • Tool offset, kinematic transformation and compensations, speed control and Interpolation
	• Position control of feed drives
	  • Control concept of a machine axis
	  • Accuracy and synchronous control of multi-axis systems
	• Measurement Systems and Sensors
	  • Measured variables in production systems
	  • Position, current acceleration, force, torque, temperature and angle measuring systems
	• Signal processing, process and condition monitoring
	  • Tasks of the process and condition monitoring
	  • Use of sensors and processing of sensor signals
	• Robots and handling systems, Robot Control (RC)
	  • Areas of application
	  • Construction and kinematics
	• Gripper technology
	  • Gripping principles
	• Mechatronic and system-oriented engineering
	  • Design and simulation software (drive design and behavior modeling)
	  • Virtual Commissioning

Learning Objectives/ Learning Outcomes	Subject-related: The students know in particular • Construction and design of mechatronic systems for production equipment • Characteristics of logical and mechanical numerical motion controls of machines • Special features of the behavior and the modeling of mechatronic components, especially for measuring and gripping technology • Concepts of machine control in various development systems, as well as machine and process monitoring • Fields of application, possibilities of an industrial engineering system and the design

	After this course, the students are able to understand the structure of mechatronic systems in the area of application of the means of production in its complexity and its context and overarching concepts of machine control systems to classify. Not subject-related: The Students can explain application areas and display the characteristics of motion controls required in machine and process monitoring. In addition, you can theoretically explain the design of an application-oriented problem and apply it to application-relevant questions. This allows the students to analyze theory-based mechatronic systems for production systems and industrial monitoring solutions and to evaluate their quality in the industrial environment. With this competence, they are able to use their own creative ideas and within the framework of the concepts known to you to develop solutions and to establish the set-up of concepts. In addition to the problem solving, they can also create control programs in various development systems and evaluate their quality.
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: Machine Tools
References	Skripte lecture and exercise for download as PDF
Language	English
Examination Terms	Written examination
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Brecher
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Mechatronics and Control Techniques for Production Plants (401145101)	1st semester	no semester recommended	5	0

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Mechatronics and Control Techniques for Production Plants	1st semester	no semester recommended	-	2
Exercise Mechatronics and Control Techniques for Production Plants	1st semester	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

– Modelling and Simulation Engineering
– Elective Courses
+ Artificial Neural Networks in Structural Mechanics (4021387)

Module titel	Artificial Neural Networks in Structural Mechanics (Compulsory elective subject)
Identifier	4021387
Version	V1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Classical structural mechanics is based on continuum mechanics using tensor calculus, differential geometry, and modelling of inelastic material behaviour. This theoretical approach established in the 20th century is the basis for finite element programs widely used in industry and science. Innovative approaches by means of artificial neural networks are known to be very efficient to describe complex mathematical dependencies. This effect relies on the self-learning ability of neural networks to reproduce dependencies between mechanical quantities such as stresses, strains, or other state variables. However, the neural network is based on experience and has therefore tobe trained by experimental or numerical data. Once the neural network has been trained, it is able to predict structural deformations in shorter calculation times than by using classical numerical approaches. Also the accuracy does not suffer, even though that program codes of neural networks are shorter than classical finite element codes. In order to apply the new knowledge on practical examples, the students will learn how to develop a virtual copy of the engineering structure by means of a neural network. Here, a wide variety of components in the network with different layers, neurons, activation functions etc. is available and must be ordered for the application. Special attention is focused on the combination of artificial neural networks with the finite element method. Following this approach, advantages of mesh generation and equation solvers in finite element programs are used and parts of the classical mechanical models are replaced by neural networks. E.g. material models are substituted by trained neural networks leading to shorter simulation times. Due to the fact that artificial neural networks are becoming more widespread in engineering disciplines, students will be familiar with this new trend in simulation methods after visiting this course. They will gain the competences to support the development of neural network enhanced modelling and simulation in industrial and scientific applications.
Learning Objectives/ Learning Outcomes	The aim of the course is to enable students to work with artificial neural networks from the viewpoint of engineering science. This implies to understand different network topologies and their applications in structural mechanics. Classical structural models will be replaced by artificial neural networks partly or completely depending on the current problem. After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> Students: • shall understand the topology of artificial neural networks • are to gain an overview and learn motivation of network architectures (weights, bias-terms, sensilivity analysis) • are to understand different network topologies and their applications in structural mechanics • shall describe mathematical models of artificial neural networks • are to describe possible applications of artificial neural networks in structural mechanics • shall model structures enhanced by neural networks • shall program artificial neural networks

	• are to find solutions for differential equations approximated by neural networks • shall develop intelligent elements and know the processes behind neural network enhanced finite element simulatios Abilities / Skills Students: • are expected to apply artificial neural networks for numerical predictions in structural mechanics • shall program neural networks and train them by data gained from experiments or simulations • shall train artificial neural networks by means of measurement and simulation data • shall model inelastic material behaviour with artificial neural networks • are expected to apply the enhancement of finite element simulation by neural networks Competencies: Students: • shall develop intelligent elements by combining neural networks with the finite element method • are to increase the efficiency of structural calculations towards faster simulations and new structural models without material parameters trained just by experimental or simulated data • are expected to choose, depending on the current problem, whether to replace classical structural models partly or completely by artificial neural networks • shall work with artificial neural networks from the viewpoint of engineering science
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: • Mechanik I-III • Nonlinear Structural Mechanics
References	• Lecture Notes • Empfohlene weiterführende Literatur: A. Engelbrecht, Computational Intelligence, An Introduction, JohnWiley Literatur & Sens, Ltd, 2007.
Language	English
Examination Terms	An oral or a written exam
Miscellaneous	-
Module coordinator	Prof. Dr.-Ing. Marcus Stoffel
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

RWTH AACHEN UNIVERSITY

– Modelling and Simulation Engineering
– Elective Courses
+ Artificial Neural Networks in Structural Mechanics (4021387)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Prüfung Artificial Neural Networks in Structural Mechanics (402138701)	1st semester	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Artificial Neural Networks in Structural Mechanics	1st semester	no semester recommended	-	2
Exercise Artificial Neural Networks in Structural Mechanics	1st semester	no semester recommended	-	2

Module titel	Digital Work: Challenges and Solutions (Compulsory elective subject)
Identifier	8016720
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	• General introduction to workplace demands and job strain • Guidelines and legal background for job design • Online Risk Assessment • Circumstantial prevention (job redesign, ergonomic changes, leadership) • Behavioural prevention (recovery)
Learning Objectives/ Learning Outcomes	Overall goal: Students gain the basic knowledge about health oriented workplace design and learn to apply the acquired methods in digital job settings. After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding Students: • understand how physical and mental job demands can impact health and well-being; • know the specific risk pattern of digital workplace settings; • are familiar with methods of circumstantial and behavioural prevention. Abilities / Skills Students: • conduct and interpret a risk assessment for digital workplaces; • have learned to consider health-outcome oriented leadership styles and behaviour; • have gained skills for self-care practices. Competencies Students: • find solutions for preventing health risks at work by following the risk assessment cycle.
(Study-Specific) Prerequisites	-
(recommended) Requirements	none
References	Lecture Notes Students also receive a list of relevant literature
Language	English
Examination Terms	written or oral examination
Miscellaneous	-
Module coordinator	Modulverantworlicher: Dr.-Ing. Alexander Mertens / Universitätsprofessorin Dr. rer. soc. Jessica Lang Modulangebotsorganisator: D. Dirkes M. Sc. RWTHModellierungsteamverantwortlicher: Sebastian Otta M. A.
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	120

– Modelling and Simulation Engineering
– Elective Courses
+ Digital Work: Challenges and Solutions (8016720)

Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Examination: Digital Work Challenges and Solutions (801672001)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise: Digital Work Challenges and Solutions	2nd semester	no semester recommended	-	2
Lecture: Digital Work Challenges and Solutions	2nd semester	no semester recommended	-	2

Module titel	Multibody Dynamics (Compulsory elective subject)
Identifier	4011462
Version	V1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2020
Valid until	-
Module level	Master
Content	• Introduction • Fundamentals • Fields of application • Model Building • Methods of Approach for Equivalent Models • Multi-body Systems • General mathematical description • Kinematics of Multi Body Systems • Position and Orientation of Bodies • Translational Kinematics • Rotational Kinematics • Equations of Motion • Lagrangian Equations of 2nd Kind • Newton-Euler equations • Lagrangian Equations of 1st Kind • Eigen Value Approach • Undamped non-gyroscopic systems • Damped gyroscopic systems • Eigen Value Stability Criteria Linear Systems with Harmonic Excitation • Real Frequency Matrix • Complex Frequency Matrix • State Equation • System Matrix • Eigen Value Approach • Fundamental Matrix • Modal Matrix • Theorem of Cayley-Hamilton • Analytical Solution • Numerical Solution • Step Excitation • Harmonic Excitation • Periodical Excitation Example • Modelling • Calculation • Evaluation
Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following: <u>Knowledge / Understanding:</u> Students: • shall have a profound knowledge of theory of vibrations. • shall be capable of comprehending, describing and analyzing vibratory systems.

	• shall be familiar with the most important matrix based procedures for the calculation of eigenmotions and the behaviour of linear systems under forced excitations. Abilities / Skills: Students • shall have the ability of describing mathematically any mechanical system with its inherent physical effects like elasticity, damping and friction. • shall be able to properly interpret simulation results especially under consideration of simplifications within the model compared to the real system. Competencies: Students • shall be able to derive from their knowledge the necessary methods and proceedings for the analysis and synthesis of the systems in regard. • shall be capable to solve - accessing their acquired theoretical knowledge - complex problems concerning the choice and design of industrial vibratory systems.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	• Lecture Notes • Students also receive a list of relevant literature
Language	English
Examination Terms	Written/Oral Examination (Depending on registration numbers)
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Dr. h. c. Burkhard Corves
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Multibody Dynamics (401146201)	2nd semester	no semester recommended	5	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Tutorial Multibody Dynamics	2nd semester	no semester recommended	-	2
Lecture Multibody Dynamics	2nd semester	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

– Modelling and Simulation Engineering
– Elective Courses
+ Numerical Methods in Mechanical Engineering (4011449)

Module titel	Numerical Methods in Mechanical Engineering (Compulsory elective subject)
Identifier	4011449
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2014
Valid until	-
Module level	Master
Content	The content of the course is to provide a map to follow the long and winding road from intuitional perception to the mathematical formulation of engineering problems. The content is summarized as follows: • Selected assumptions and mathematical tools to formulate problems • An overview of several solution methods: analytical solutions, approximate solutions, direct approximation, approximate solution after transformation of the problem • An overview of selected types of physical problems: discrete systems, continuous systems, equilibrium problems, eigenvalue problems, propagation problems • Integral formulations • Weak formulation of problems • The Method of Weighted Residuals • Introduction to variational calculus • Functionals • Functionals associated with an integral form • The stationarity principle • Stationarity conditions • Examples from mechanics • The method of Lagrange multipliers • Mixed and complementary formulations • Catalogue of functionals used in continuum mechanics and their specific features • Discretisation of integral forms • Collocation by points • Collocation by subdomains • Galerkin’s method Least Squares Method Examples • Ritz' method • Examples • Numerical integration • Newton-Cotes method • Gauss method Examples: • The Finite Element Method, Shape functions, construction of finite elements • Matrix representation in the FEM, Stiffness matrix, Boundary conditions • Examples from structural engineering, Software packages in engineering
Learning Objectives/ Learning Outcomes	Overall goal: The students will gain theoretical background of numerical methods commonly used in mechanical engineering. In particular, the physical formulations are discussed based on which the corresponding mathematical formulations for large-scale numerical methods are presented. In this course, students shall acquire the following:

	Knowledge / Understanding The students will understand • the theoretical foundations of current numerical methods in engineering • the bridge between the physical formulation of a problem and the mathematical description suited to implement numerical approximation methods • the steps and transformations required to implement numerical methods Abilities / Skills The students are able to • apply approximation techniques and analyse the results obtained by various numerical methods • use their acquired knowledge to develop state-of-the-art approximation methods • critically judge the consistency and correctness of numerical methods • apply variational methods to obtain formulations of a problem of differential equations • construct basis functions compatible with the boundary conditions • construct and apply a variety of approximation methods based on the WRM (collocation by points, collocation by subdomains, Galerkin's method, least squares method, Ritz method) • solve constrained optimization problems by using the Lagrange Multipliers Method • construct the associated energy potential and to apply the stationary principle for a conservative mechanical problem • apply basic tools of numerical integration
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	• Lecture Notes • Dhatt, G., Touzot, G.: The Finite Element Method Displayed. Wiley, New York, 1984. • Finlayson, B.A.: The Method of Weighted Residuals and Variational Principles. Academic Press, New York, 1972. • Reddy, J.N.: Energy and Variational Methods in Applied Mechanics. Wiley, New York, 1984. • Lemaitre, J., Chaboche, J.-L.: Mechanics of Materials, Cambridge Univ. Press, Cambridge, 1994. • König, J.A.: Shakedown of Elastic-Plastic Structures. Elsevier, Amsterdam, 1987.
Language	English
Examination Terms	Written exam or oral exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Bernd Markert Dr. rer. nat. Michael Ban
ECTS Credits	7
Contact time (WSH)	5
Examination duration (min)	-
Total hours (h)	210,0
Contact hours (h)	75,0
Self-study hours (h)	135,0

RWTH AACHEN UNIVERSITY

– Modelling and Simulation Engineering
– Elective Courses
+ Numerical Methods in Mechanical Engineering (4011449)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Numerical Methods in Mechanical Engineering (401144901)	1st semester	no semester recommended	7	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Numerical Methods in Mechanical Engineering	1st semester	no semester recommended	-	3
Tutorial Numerical Methods in Mechanical Engineering	1st semester	no semester recommended	-	2

– Modelling and Simulation Engineering
– Elective Courses
+ Mechanics of Engineering Materials (4011448)

Module titel	Mechanics of Engineering Materials (Compulsory elective subject)
Identifier	4011448
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2017
Valid until	-
Module level	Master
Content	The course aims at the understanding of the behaviour of engineering materials such as metals, plastics, and carbon fiber-reinforced composites. The major objective is the development and discussion of appropriate material models for elastic and inelastic materials. Further, the numerical treatment of these models will be addressed in the context of the finite element method. Finally, the according parameters will be identified by comparison with experiments. In particular, the following aspects will be addressed: • Elasticity at small and finite strains • Thermo-elasticity • Anisotropic elasticity for composites • Viscoelasticity – Creep an relaxation • Plasticity and hardening • Damage and crack initiation • Parameter identification
Learning Objectives/ Learning Outcomes	After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding Students: • know the different phenomena which can be observed in experiments; • know the different material models which have been proposed to describe these phenomena; • understand the basic concept of how to achieve an appropriate material model. Abilities / Skills Students: • analyse analytical and numerical results with respect to the quality of the adopted model; • predict the material response to a given loading scenario. Competencies Students: • critically assess the applicability and correctness of material models; • transfer theoretical models to actual engineering problems from the fields of mechanical, civil, and aeronautical engineering.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-
References	Lecture Notes, AudioSlides Students also receive a list of relevant literature
Language	English
Examination Terms	A written or oral exam
Miscellaneous	-
Module coordinator	Dr.-Ing. Jaan-Willem Simon
ECTS Credits	5

– Modelling and Simulation Engineering
– Elective Courses
+ Mechanics of Engineering Materials (4011448)

Contact time (WSH)	3
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	45,0
Self-study hours (h)	105,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Mechanics of Engineering Materials (401144801)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Mechanics of Engineering Materials	2nd semester	no semester recommended	-	1
Lecture Mechanics of Engineering Materials	2nd semester	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

– Modelling and Simulation Engineering
– Elective Courses
+ Tensor Algebra and Tensor Analysis for Engineers I (4012288)

Module titel	Tensor Algebra and Tensor Analysis for Engineers I (Compulsory elective subject)
Identifier	4012288
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2009
Valid until	-
Module level	Master
Content	• Notion of the vector space • Geometrical illustration of vectors • Examples of vector spaces • Basis and dimension of the vector space • Components of a vector, summation convention • Scalar product of vectors, Euclidean space • Orthonormal basis • Dual basis • Second-order tensor as a linear mapping • Right and left mapping • Tensor product • Representation of a tensor with respect to a basis • Change of the basis, transformation rules • Special operations with second-order tensors • Tensor functions, exponential tensor function • Transposition, symmetric and skew-symmetric tensors • Inversion • Scalar product of tensors • Decomposition of second-order tensors • Vector and tensor valued functions, differential calculus • Coordinates in Euclidean space, tangent vectors • Coordinate transformation, covariant and contravariant components • Gradient, covariant derivative • Christoffel symbols, representation of the covariant derivative • Mock-Examination
Learning Objectives/ Learning Outcomes	Tensor algebra is the language of modern continuum mechanics and material theory. Due to the course the students will be able to read and understand modern scientific literature in this area, formulate and interpret tensor identities in absolute as well as index notation. The knowledge obtained within the course is also very helpful for the numerical implementation of finite element procedures.
(Study-Specific) Prerequisites	-
(recommended) Requirements	recommended: • Basic knowledge of mathematics and in particular matrix algebra
References	• Halmos, P.R. Finite-Dimensional Vector Spaces. Van Nostrand, New York, 1958. • Itskov, M. Tensor Algebra and Tensor Analysis for Engineers with Applications to Continuum Mechanics, Springer, 2007.
Language	English
Examination Terms	Written exam
Miscellaneous	-

– Modelling and Simulation Engineering
– Elective Courses
+ Tensor Algebra and Tensor Analysis for Engineers I (4012288)

Module coordinator	Universitätsprofessor Dr.-Ing. (RUS) Mikhail Itskov
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Examination Tensor Algebra and Tensor Analysis for Engineers I (401228801)	1st semester	no semester recommended	5	0
Exercise Tensor Algebra and Tensor Analysis for Engineers I (401228802)	1st semester	no semester recommended	0	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Vorlesung Tensor Algebra and Tensor Analysis for Engineers I	1st semester	no semester recommended	-	2

– Modelling and Simulation Engineering
– Elective Courses
+ Simulation of Discrete Event Systems (4011437)

Module titel	Simulation of Discrete Event Systems (Compulsory elective subject)
Identifier	4011437
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2020
Valid until	-
Module level	Master

Content	• Definition of Discrete Event Systems and fundamentals of simulation, modelling and application
	• Deterministic approaches
	  • Languages, various kinds of automata, automata-generated languages
	  • Properties and relations of state charts
	  • Petri nets and coverability trees
	  • Timed models
	• Stochastic approaches
	  • Stochastic timed models
	  • Markov Chains and Variable Length
	  • Queuing models
	  • Bayesian Networks and Dynamic Bayesian Networks
	• Event scheduling schemes and output analysis with terminating and non-terminating simulations

Learning Objectives/ Learning Outcomes	After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding Students • shall know important theories and techniques for modelling discrete event systems; • shall understand the principles of simulation based on advance approaches. Abilities / Skills Students: • shall be able to analyse real systems and build quantitative models of these systems using the proposed methods for analysis and simulation; • shall be able to predict future states and properties of the modelled systems using the proposed methods for analysis and simulation; • shall be able to predict future states and properties of the modelled systems. Competencies Students: • shall learn to describe, analyse and evaluate event systems, apply their knowledge and skills to real-life engineering systems and come to well-founded conclusions; • are to understand how to model robust, effective and efficient systems which improve the satisfaction and the safety of the persons involved.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	• Lecture Notes • Students also receive a list of relevant literature

– Modelling and Simulation Engineering
– Elective Courses
+ Simulation of Discrete Event Systems (4011437)

Language	English
Examination Terms	Written exam
Miscellaneous	-
Module coordinator	Univ.-Prof. Dr.-Ing. Verena Nitsch
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Simulation of Discrete Event Systems (401143701)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Simulation of Discrete Event Systems	2nd semester	no semester recommended	-	2
Exercise Simulation of Discrete Event Systems	2nd semester	no semester recommended	-	2

– Modelling and Simulation Engineering
– Elective Courses
+ Additive Manufacturing: Technologies and Processes (4017421)

Module titel	Additive Manufacturing: Technologies and Processes (Compulsory elective subject)
Identifier	4017421
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2021
Valid until	-
Module level	Master
Content	1) Introduction: motivation, market relevance, overview of relevant technologies 2) selective laser melting: process principle, develpoment of process strategies, quality and cost optimization, high power slm 3) laser metal deposition: process princlple, workflow and productivity, best practice examples 4) selective laser sintering & stereolithography: process principle, workflow and productivity, best practice examples 5) thin film processing: process principle, workflow and productivity, best practice examples 6) material & process control: material classes, properties and applications, material production and quality assurance, quality aspects within additve manufacturing, system technology and sensor technology, controlling and monitoring of laser manufacturing processes 7) design for additive manufacturing I: agil project management within additive manufacturing, extension of the CAE process chain, AM software, AM confirm product development 8) design for additive manufacturing II: simulation driven design process (topology optimization, integration of lattice structures, function integration) 9) production planning I: job preperation (data control and mesh repair, CAM (SLM vs. LMD), part placement & material handling, work safety and environment 10) production planning II: simulation (mold dynamics, heat transfer, structure, tension, protective atmosphere and gas flow, und nozzle design) 11) subsequent processes: heat treatment, surface finishing, hybrid application, automatization concepts. 12) application and market: present applications & expectet developments, efficiency, intellectual property 13) summary and future trends: key properties of AM technologie, overview of the physical and digital processchain, outlook
Learning Objectives/ Learning Outcomes	Knowledge and comprehension: - the students have knowledge of significant AM - technologies and their fundamental properties and applications - the students are in the position to differentiale AM - technotogies from conventional production processes - the students have knowledge of AM - specific construction rules and simulation driven design processes - the studends know essential pre- and post processes and interdependencies along the digital and physical process chain

	- the students know major factors of key determinants on the economic application of AM - technology - the students have knowledge of content-related aspects which correspond to present applications and expected developments Skills and competencies: - the students are able to develop own strategies and solutions to prescribed scientific issues
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: - knowledge in production technology - knowledge in heat and mass transfer - knowledge in laser technology
References	Vorlesungsskript, Übungsaufgaben
Language	German/English
Examination Terms	Exam
Miscellaneous	-
Module coordinator	Modulverantworlicher: Universitätsprofessor Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Additive Manufacturing: Technologies and Processes (401742101)	1st semester	no semester recommended	6	0

− Modelling and Simulation Engineering
− Elective Courses
+ Additive Manufacturing: Technologies and Processes (4017421)

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Additive Manufacturing: Technologies and Processes	1st semester	no semester recommended	-	2
Lecture Additive Manufacturing: Technologies and Processes	1st semester	no semester recommended	-	2

Module titel	Linear Control Systems (Compulsory elective subject)
Identifier	4011476
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	Significance of control theory, examples of biological and biomedical control loops, functional diagrams, linearization, set up and solving of differential equations, stability, features in time domain of dynamical systems, Laplace transform, transfer function, frequency response, functional diagram algebra, features in frequency domain of dynamical systems, bode diagram, Nyquist plot, Linear control loop elements, principle and goals of controller design, algebraic stability criteria, steady state analysis and transient performance of a control loop, controller setting rules, Nyquist stability criterion, phase margin, gain margin, controller design in bode diagram.
Learning Objectives/ Learning Outcomes	After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: • know, recognize and classify the most common linear control loop elements • the effects of feedback and apply different methods to set up feedback elements (controllers) such that predefined control goals are met Abilities / Skills: • to analyze dynamical, biological and biomedical systems and identify the relevant causalities • to employ different mathematical descriptions of dynamical systems • solve differential equations by means of Laplace transform • assess of the stability of dynamical systems using different methods • obtain, interpret and employ the frequency response of dynamical systems
(Study-Specific) Prerequisites	-
(recommended) Requirements	Basic knowledge in mathematics as defined in the examination regulations.
References	-
Language	English
Examination Terms	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)
Miscellaneous	-
Module coordinator	Prof. Dr.-Ing. Heike Vallery
ECTS Credits	3

Contact time (WSH)	2
Examination duration (min)	-
Total hours (h)	90,0
Contact hours (h)	30,0
Self-study hours (h)	60,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Linear Control Systems (401147601)	1st semester	no semester recommended	3	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Linear Control Systems	1st semester	no semester recommended	-	1
Tutorial Linear Control Systems	1st semester	no semester recommended	-	1

RWTH AACHEN UNIVERSITY

– Modelling and Simulation Engineering
– Elective Courses
+ Optimization and Lightweighting of Structures (4011411)

Module titel	Optimization and Lightweighting of Structures (Compulsory elective subject)
Identifier	4011411
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2024
Valid until	-
Module level	Master
Content	1. Introduction to design methodology - Purposes of technical systems; Methods to derive requirements and setting up re-quirements lists - Development of technical concepts: Function structures; Discursive, heuristic and empiric methods for problem solving - Concept evaluation: Methods to evaluate and select among variants - Rules and principles of Embodiment Design - Design for X 2. Introduction to Lightweighting - Definition and general principles of lightweighting - How to compare the performance of materials? 3. Modelling and computation of loads - Statically indeterminate systems - Stresses of thin-walled structures due to transverse shear, torsion and warping-torsion 4. Modelling and computation of nonlinearities - Physical nonlinearity: Plastic bending and plastic hinge theory, composite beams - Beam theory under large deformations (Th. II. Order) 5 Stability of lightweight structures - Stability of beams - Stability of plates and shells 6. Optimization of structures - Lagrange multiplyers Topology optimization
Learning Objectives/ Learning Outcomes	Technical competencies – knowledge and skills After completing the module, students will be able to - describe and apply the product development process according to VDI 2221 along all its phases - describe methods of solution synthesis - use methods for systematic solution generation and evaluation - describe and apply the basic principles of lightweighting to create weight-optimised structural designs - calculate the load on common beam structures - comprehensively calculate the stresses in thin-walled structures - describe and model physical and geometric non-linearity in the structural response - describe stability phenomena for lightweight structures and calculate the corre-sponding structural part resistances - perform weight optimisation of load-bearing structures - analyse the structural response of lightweight structures - identify the potential for weight saving in existing structures Interdisciplinary competencies – methodic-, social-, and self-competence

	After completing the module, students will be able to - identify requirements in projects - analyse and describe technical problems - systematically find solutions to technical problems - evaluate these solutions - synthesise solution principles for technical problems
(Study-Specific) Prerequisites	-
(recommended) Requirements	Statics, elastostatics, dynamics
References	• Pahl, G. Beitz, W.: Engineering Design. Springer, 2007. • Roark, R. J., Young, W. C.: Formulas for Stress and Strain, McGraw-Hill, 1975. • Jones, R. M.: Mechanics of Composite Materials, McGraw-Hill, 1975. • Bruhn, E. F.: Analysis and Design of Flight Vehicles Structures. • Niu, M. C. Y.: Airframe Structural Design, Conmilit Press Ltd., 1988.
Language	English
Examination Terms	One written examination
Miscellaneous	-
Module coordinator	Prof. Dr.-Ing. Kai-Uwe Schröder
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	120 minutes
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Optimization and Lightweighting of Structures (401141101)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Optimization and Lightweighting of Structures	1st semester	no semester recommended	-	2

Lecture Optimization and Lightweighting of Structures	1st semester	no semester recommended	-	2

Module titel	Production Management A (Compulsory subject)
Identifier	4011477
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2013
Valid until	-
Module level	Master
Content	• From Taylorism to Industry 4.0 • Business Process Modelling • Production Optimization • Lean Production - Production Systems • Structured Innovation Process • Variant management • Product Planning and Engineering • Technology Planning • Manufacturing and Assembly Planning • Process Planning • Materials Management • Production Planning and Control • Global Production Networks • Factory Planning
Learning Objectives/ Learning Outcomes	Markets and manufacturing conditions are frequently changing. This imposes the necessity of long-range and intensive planning in enterprises of the manufacturing industry, as only early accommodation of actual conditions guarantees competitiveness. Students shall gain knowledge which topics have to be considered in this context and how this knowledge can be transferred to daily business of a company. For the purposes of manufacturing engineering, students are expected to know the following tasks that have to be carried out. In this course, students shall acquire the following: <u>Knowledge / Understanding</u> Students • shall elaborate and apply planning methods. • are to analyze problems in all enterprise domains which are involved in the manufacturing process. • shall be able to demonstrate possibilities for rationalisation and automation. • shall know elaboration of rationalisation methods and tools. • are expected to understand the problems of producing companies. These tasks are elucidated concerning the manufacturing domains design, operations planning and scheduling, production and assembly as well as the overall organization. • shall understand the problems of producing companies and find solutions best suited for the investigated subject. • shall understand the complex problems of producing companies and have the knowledge to identify critical parameters by considering performance indicators <u>Abilities / Skills</u> Students • shall apply this knowledge to elaborate possibilities for rationalization and automation issues;

	• shall analyse problems in all enterprise domains which are involved in the manufacturing process. Competencies Students • shall elaborate rationalization methods and tools; • shall find solutions best suited for the investigated subject in concerning the manufacturing domains design, operations planning and scheduling, production and assembly as well as the overall organization.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	• Kurbel, K. E. (Enterprise Resource Planning): Enterprise Resource • Planning and Supply Chain Management. Functions, Business Processes and Software for Manufacturing Companies, 2013 • Hans-Peter Wiendahl, Jürgen Reichardt, Peter Nyhuis, Handbook Factory Planning and Design, 2015 • Peter Nyhuis, Hans-Peter Wiendahl, Fundamentals of Production • Logistics: Theory, Tools and Applications, 2008 • Lecture Notes • Students also receive a list of relevant literature
Language	English
Examination Terms	Written exam or oral exam
Miscellaneous	-
Module coordinator	Dr.-Ing. Michael Riesener
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Production Management A (401147701)	3rd semester	no semester recommended	5	0

− Digital Engineering
− Compulsory Courses
+ Production Management A (4011477)

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Production Management A	3rd semester	no semester recommended	-	2
Lecture Production Management A	3rd semester	no semester recommended	-	2

Module titel	Embedded Systems (Compulsory subject)
Identifier	1215690
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Embedded systems control many things in our daily life. Energy-efficient refrigerators, elevator controls, and advanced driver assistance systems are just some examples. Embedded systems also control processes in industrial environments and are used to detect and prevent system failures. This lecture gives a general introduction to the topic of embedded systems. It introduces basic concepts and points out important differences to “normal” computer systems. This lecture prepares students for advanced lectures of the Embedded Software Laboratory that cover safety, reliability, formal methods and dynamic systems in detail. This lecture is targeted at all students that do not want to limit themselves to understanding PCs but also want to know how, for example, engine control units and production control systems work. Topics covered in this lecture are: Microcontroller, Programmable logic controllers (PLCs, PLC programming languages, Real-time requirements, Real-time operating systems, Characteristics of embedded software design, Intra vehicle communication (e.g., CAN bus), Teasers of advanced lectures of the embedded software laboratory, The lecture will be held in German with English slides.
Learning Objectives/ Learning Outcomes	Knowledge: Knowledge and confidence in modern software techniques for embedded systems | Skills: Ability to apply a model-based quality-oriented approach for the design of embedded software | Competences: Sensibility for special qualitative requirements for the design of embedded software
(Study-Specific) Prerequisites	-
(recommended) Requirements	Knowledge of “Foundations of Technical Computer Science”.
References	Slides of the lecture, script and the following books: Marwedel: Eingebettete Systeme. 2003 | Bass, Clements: Software Architecture in Practice. | Douglass: Real-time UML
Language	English
Examination Terms	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Stefan Kowalewski
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	150,0

Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Embedded Systems (121569002)	2nd semester	no semester recommended	0	1
Exam Embedded Systems (121569001)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Embedded Systems	2nd semester	no semester recommended	-	3

– Digital Engineering
– Compulsory Courses
+ Manufacturing Technology II (4011447)

Module titel	Manufacturing Technology II (Compulsory subject)
Identifier	4011447
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2021
Valid until	-
Module level	Master
Content	Fundamentals: • Signatures of manufacturing processes • Tribology • Material specific challenges in cutting • High performance cutting • Forming technology • FEM-Simulation in manufacturing technology • Computer-aided technology planning • Process data • Productivity and profitability Branches: • Tool making • Propulsion technology • Gear making technologies • Optics
Learning Objectives/ Learning Outcomes	Wissen und Verstehen: Students acquire in-depth knowledge of desirable and undesirable manufacturing-related property modifications in the rim zone and in the interior of the component. They understand and model tribological effects and master material-specific challenges in cutting. They know: - Current developments in high-performance machining, - Latest trends in forming technology, - Fundamentals of FEM simulation of cutting and forming processes, - Possibilities for computer-aided design and optimization of manufacturing processes, - Current approaches to control manufacturing processes,

	- Key figures for the description of productivity and efficiency of manufacturing processes and basics of static test methodology, - Approaches of digitization in the addressed areas. They are familiar with the manufacturing technology challenges and current solution approaches in branches: - Tool making, - Optics, - Propulsion and gear making technology. This enables them to apply their knowledge to future development tasks. Fertigkeiten und Kompetenzen: Students can analyze and optimize manufacturing processes against a broad technological background. They are able to plan series of experiments based on hypotheses and take into account technological relationships of cause and effect. Moreover, they are able to further develop existing manufacturing processes and identify alternatives.
(Study-Specific) Prerequisites	-
(recommended) Requirements	Empfohlene Voraussetzungen: Manufacturing Technology I
References	-
Language	English
Examination Terms	A written or an oral exam
Miscellaneous	-
Module coordinator	Univ.-Prof. Dr.-Ing. Thomas Bergs
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Manufacturing Technology II (401144701)	2nd semester	no semester recommended	5	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Manufacturing Technology II	2nd semester	no semester recommended	-	2
Tutorial Manufacturing Technology II	2nd semester	no semester recommended	-	2

– Digital Engineering
– Compulsory Courses
+ International Factory Planning (4011481)

Module titel	International Factory Planning (Compulsory subject)
Identifier	4011481
Version	V3
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2021
Valid until	-
Module level	Master
Content	L1 - Introduction to Factory Planning & Project Management: • basic glossary, different viewpoints, challenges and requirements of factory planning L2 - Target Definition & Product/Process Planning: • definition of objectives with the involvement of different stakeholders and requirements • challenges and approaches of product and process planning within the framework of factory design L3 - Location Planning & Site Structure Planning: • current trends in site structure planning and methods for evaluating different plant structure alternatives in order to create a basis for one of the most essential decisions within the factory planning process L4 - Industrial Building & Building Planning: • factory planning on the building side, i.e. advantages and disadvantages of different bearing structures, roof constructions and facade types L5 - Production Structure Planning & Capacity Planning: • production structure within the plant according to the site structure planning • challenges and approaches of capacity planning L6 - Layout Planning & Workplace Design: • overview of the goals and challenges of layout planning and the even more detailed workplace design L7 - Highlight lecture: • state-of-art application of modern factory planning methods
Learning Objectives/ Learning Outcomes	Within the framework of the lecture Factory Planning, the state-of-the-art of the respective subject areas will be introduced, relevant methods and procedures will be explained and reference solutions will be presented. The contents will be deepened in the exercises and in the case study. In this way, future production managers will be able to comprehensively plan and develop individual production sites as well as entire production networks of internationally active companies. The lectures and exercises as weil as the case studies are only held in summer semesters. The case studies are conducted in group work. A successful registration for the module Factory Planning already at the very beginning of each summer semester is therefore vital in order to be integrated within the allocation to groups. Each group then collaborates as a planning team to work on the case study, but members are graded individually. However, the exam can be written each semester, which means that the requirement of the case study has to be fulfilled (passed with a grade of 4.0 or better) to take the exam. If an exam is failed, but the case study has already been completed, the grade of the case study is credited in the following semester. The aim of these case studies is to deepen the contents conveyed in the lecture in a practical application. The students are presented with a real-world-oriented factory planning problem. In order to successfully perform an extensive analysis covering multiple planning levels and give decision-targeted recommendations, the concepts and methods learned from the lectures

	and excercises need to be rigorously applied. By emulating a real factory planning project, students are prompted to work together and transfer their knowledge into practice. In addition, the developed solutions are to be validated using simulation tools provided by the chair, e.g. for verifying material flows. Finally, the used procedures and achieved results are compiled into a case study report. The case study work is expected to run from May to June in the summer semester and must therefore be submitted before the written exam phase. Knowledge / Understanding - describe the characteristics and challenges of factory planning and with regard to the global environment - formulate the object precisely and in a detailed way - have an extended understanding of state of the art planning process of factories - know and understand the definition of the own value adding scope, the choice and allocation of suitable production locations, the conception of production systems and the usage of suitable planning tools. - understand the procedures and methods in factory planning Abilities / Skills - apply the acquired methods to design a factory - apply this knowledge to analyse organizational structures and forms of production Competencies - analyse the initial situation of a factory planning project, draft and classify possible solutions - define and develop single production plants as well as production networks of globalized companies and explain them to different target groups
(Study-Specific) Prerequisites	-
(recommended) Requirements	-
References	Lecture reprint Exercise reprint Sample solution reprint
Language	English
Examination Terms	The final grade is composed to 2/3 of the exam grade and to 1/3 of the case study grade (individual grading). Both parts have to be passed in order to pass the whole module. Bonus points are awarded for the e-Test in L2P: Tests with 5-6 questions per lecture unit; time limited to 30 minutes activation from the day of the lecture to the day before the following lecture or max. 1 week > 50% of questions correct (i.e. 3 questions) - > test passed! 1 bonus point per test-> Max. 6 bonus points reachable (5% of all points reachable in the exam)
Miscellaneous	-
Module coordinator	Univ.-Prof. Dr.-Ing.Günther Schuh
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0

Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam International Factory Planning (401148101)	2nd semester	no semester recommended	3.3	0
Case Study International Factory Planning (401148102)	2nd semester	no semester recommended	1.7	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise International Factory Planning	2nd semester	no semester recommended	-	2
Lecture International Factory Planning	2nd semester	no semester recommended	-	2

Module titel	Advanced Finite Element Methods for Engineers (Compulsory elective subject)
Identifier	4013866
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	Content • General introduction, concept of the finite element method • Symbolic assembly procedure • Global and local coordinates • Stiffness matrix for trusses / coordinate transformation • Variational techniques • Solution of truss structures • Variational techniques, Euler-Lagrange equation • Natural and forced boundary conditions • Multiple integrals, Gauss-Theorem • Variations of elementary algebraic functions • Variational principle for linear self-adjoint diff. operators • Solution of some classical variational problems • Principle of virtual work as a weak form of the momentum balance, variational principles of mechanics (Lagrange, Hu-Washizu) • Differential equation of a linear elastic bar, analytic solution for various load cases • Rayleigh-Ritz method, weighted residual approximations, Point or subdomain collocation • Galerkin method, least-squares method, linear elastic bar approximated by a continuous shape function • Displacement formulation • Three-field (mixed) formulation • Examples to weighted residual approximations • Requirements to shape functions • Continuous shape functions, piecewise defined shape functions, approximation by piecewise defined shape functions. • 2-d problems of elasticity, triangular element, plain strain and plane stress problems, • Torsion of a prismatical bar • Examples for plain strain and plane stress problems discretized by linear triangular elements

	• Axisymmetric stress analysis, 3-d stress analysis • Construction of 2-d and 3-d finite elements (Lagrange and serendipity family) • Concept of hierarchical shape functions • Concept of mapping in iso-parametric finite elements • Application of numerical integration in 1-d, 2-d and 3-d finite element problems • Non-linear finite element problems (Newton-Raphson method) • Dynamic (time-dependent) finite element problems, time step size and mass scaling
Learning Objectives/ Learning Outcomes	The aim of the course is to impart the basic knowledge about finite element methods and their application to solid and structural mechanics. The students will • understand why the FE-Method and the other numerical methods behind are important for engineering practice • understand the basic concept of FEM • be able to find solutions for trusses with a variety of boundary conditions • understand the fundamental concept of variational calculus • be able to find solutions for mechanical problems by using weighted residual methods • be able to use finite element method for plane strain, plane stress and torsion problems • be able to construct finite elements with linear and non-linear shape functions • understand the application of numerical integration in finite element method • understand the concept of non-linear and time-dependent finite element problems In addition, voluntary programming exercise sessions are offered to deepen the theoretical understanding. A simple FEM solver is developed in Python, numerical integration schemes are discussed and the FEniCS programming package is introduced.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-
References	-
Language	English
Examination Terms	Written exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. (RUS) Mikhail Itskov
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0

Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Advanced Finite Element Methods for Engineers (401386601)	2nd semester	no semester recommended	5	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Finite Element Methods for Engineers	2nd semester	no semester recommended	-	2
Tutorial Advanced Finite Element Methods for Engineers	2nd semester	no semester recommended	-	2

Module titel	Artificial Intelligence and Data Analytics for Engineers (Compulsory elective subject)
Identifier	4018567
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	Artificial Intelligence and Data Analytics for Engineers • Introduction to Data Analytics and Artificial Intelligence in Engineering: Goals, Challenges, Obstacles, and Processes • Data Preparation: Cleansing and Transformation • Data Integration: Architectures, Challenges, and Approaches • Data Representation: Feature Extraction and Selection • Data-Driven Learning: Supervised (Classification, Regression) and Unsupervised Learning (Clustering) for Engineers • State-of-the-Art Methods: Reinforcement Learning and Deep Neural Networks (GANs, CNNs, Restricted Boltzman Machines etc.) • Data Mining and Visual Analytics
Learning Objectives/ Learning Outcomes	Artificial Intelligence and Data Analytics for Engineers Overall goal: Students gain the application-specific knowledge about artificial intelligence (especially: machine learning as supervised, unsupervised and reinforcement learning) and data analytics (especially: data exploration, data mining, data visualization and interpretation of analysis results) for application in the engineering domain. After successfully completing this course, the students will have achieved the following learning outcomes: Knowledge / Understanding Students • obtain a comprehensive view of the challenges in the application and usage of artificial intelligence and data analytics in the engineering domain; • are familiar with fundamental concepts and methods of machine learning and data mining in the engineering domain; • know and understand the different steps (cleansing, transformation and extraction) necessary to analyse and to use data in various engineering scenarios; • know about the application scope of specific methods and their strength as well as their limits; • obtain a view on specific evaluation methods with regards to the choice of analysis method and the underlying data; • are familiar with the intricacies of interpreting analysis results with regards to the utilized analysis methods and evaluation method. Abilities / Skills Students • learn how to use and apply the methods and concepts in engineering tasks correctly; • learn to distinguish between different analysis and learning scenarios and how to approach engineering related challenges; • learn the basics of state of the art tools that are used for AI data analytics in the engineering domain; • learn to choose the appropriate tools for the different steps of the knowledge discovery and artificial learning process. Competencies Students • independently evaluate analysis scenarios in the engineering context and select suitable methods accordingly; • find solutions for different analysis scenarios; • have practical and applicable knowledge about data analytics and machine learning for engineering purposes; • use tools used in the machine learning and data analytics domain and reflect the usage; • can combine single tools into a toolchain for an analysis pipeline to address complex problems in the engineering domain.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	Lecture Notes; Students also receive a list of relevant literature

– Digital Engineering
– Compulsory Courses
– Advanced Finite Element Methods or ...
+ Artificial Intelligence and Data Analytics for Engineers ...

Language	English
Examination Terms	A written exam or an oral exam
Miscellaneous	-
Module coordinator	Dipl.-Inform. Christian Kohlschein
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	0
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Artificial Intelligence and Data Analytics for Engineers (401856701)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Artificial Intelligence and Data Analytics for Engineers	2nd semester	no semester recommended	-	2
Exercise Artificial Intelligence and Data Analytics for Engineers	2nd semester	no semester recommended	-	2

– Digital Engineering
– Elective Courses
+ Machine Tools (4011460)

Module titel	Machine Tools (Compulsory elective subject)
Identifier	4011460
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2013
Valid until	-
Module level	Master
Content	1 • L: An introduction to the machine tool design and machine tools for forming • E: Metal-forming machines 2 • L: Metal-cutting maschines with geometrically defined and undefined cutting edges • E: Tour around the shop floor of WZL and IPT 3 • L: Design of mounts and mount components with respect to the static behavior • E: Design of structural components and software tools for the design of machine tools 4 • L: FEM, Multi-Body-Simulation, Machine Foundations • E: Finite-Element-Analysis 5 • L/E: Hydrodynamic and hydrostatic guideways and bearings 6 • L: Ball screws, spindle bearing systems, seals and covers • E: Bearing, spindle bearing systems 7 • L: Structure of feed drives, mechanical components of feed drives, position measuring systems and control systems • E: Layout of the mechanical components of feed drives 8 • L/E: Inverters and Drives 9 • L/E: Measuring instruments, geometric and kinematic behavior of machine tools 10 • L/E: Static, kinematic and thermal behavior of machine tools, Introduction tot he dynamics 11 • L/E: Metrological analysis of the dynamic behavior of machine tools 12 • L: Acoustic behavior of machine tools • E: Principles of noise measurement and rating 13 • L/E: Exam preparation
Learning Objectives/ Learning Outcomes	Subject-related: his course will provide participants with advanced knowledge about the most important machine types as well as their application fileds and the associated machine components. After the course students will know the basic characteristics of the machines and their components as well as their function. Thus they are able to distinguish typical machine tools and describe their functions. In addition, students will be able to explain the basic tasks and functions of machine programming and control as well as the drive control. Not subject-related: he students can derive the properties of the machines and their components theoretically or analytically/numerically and derive the necessary design variables. In this way, they are able to examine the importance of the individual components with respect to the whole machine

	system. Furthermore, the students are able to transfer their knowledge of the programming, control and drive control of machines to specific applications. The students are able to assess the suitability of machine tools in relation to a given requirement profile.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-
References	Skripte lecture and exercise for download as PDF
Language	English
Examination Terms	Written exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Brecher
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Machine Tools (401146001)	1st semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Machine Tools	1st semester	no semester recommended	-	2
Lecture Machine Tools	1st semester	no semester recommended	-	2

Module titel	Mechatronics and Control Techniques for Production Plants (Compulsory elective subject)
Identifier	4011451
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2013
Valid until	-
Module level	Master

Content	• Indroduction of Mechatronics and Control Techniques for Production Plants
	• Mechanical controls
	  • Machine elements of mechanical controls
	  • Application examples for mechanical controls
	• Information processing in mechatronic systems
	  • Theory and examples of embedded systems
	  • Programming of embedded systems and logical controls
	• Programmable Logic Control (PLC) and Motion Control (MC)
	  • Programming of programmable logic controllers
	  • Test methods of programmable logic controllers (HIL)
	• Numerical Control 1: Design, programming, CAM
	  • NC programming procedures (manual and workshop-oriented)
	  • NC programming of CAM systems
	• Numerical Control 2: Interpolation
	  • Structure of an NC control
	  • Tool offset, kinematic transformation and compensations, speed control and Interpolation
	• Position control of feed drives
	  • Control concept of a machine axis
	  • Accuracy and synchronous control of multi-axis systems
	• Measurement Systems and Sensors
	  • Measured variables in production systems
	  • Position, current acceleration, force, torque, temperature and angle measuring systems
	• Signal processing, process and condition monitoring
	  • Tasks of the process and condition monitoring
	  • Use of sensors and processing of sensor signals
	• Robots and handling systems, Robot Control (RC)
	  • Areas of application
	  • Construction and kinematics
	• Gripper technology
	  • Gripping principles
	• Mechatronic and system-oriented engineering
	  • Design and simulation software (drive design and behavior modeling)
	  • Virtual Commissioning

Learning Objectives/ Learning Outcomes	Subject-related: The students know in particular • Construction and design of mechatronic systems for production equipment • Characteristics of logical and mechanical numerical motion controls of machines • Special features of the behavior and the modeling of mechatronic components, especially for measuring and gripping technology • Concepts of machine control in various development systems, as well as machine and process monitoring • Fields of application, possibilities of an industrial engineering system and the design

	After this course, the students are able to understand the structure of mechatronic systems in the area of application of the means of production in its complexity and its context and overarching concepts of machine control systems to classify. Not subject-related: The Students can explain application areas and display the characteristics of motion controls required in machine and process monitoring. In addition, you can theoretically explain the design of an application-oriented problem and apply it to application-relevant questions. This allows the students to analyze theory-based mechatronic systems for production systems and industrial monitoring solutions and to evaluate their quality in the industrial environment. With this competence, they are able to use their own creative ideas and within the framework of the concepts known to you to develop solutions and to establish the set-up of concepts. In addition to the problem solving, they can also create control programs in various development systems and evaluate their quality.
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: Machine Tools
References	Skripte lecture and exercise for download as PDF
Language	English
Examination Terms	Written examination
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Brecher
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Mechatronics and Control Techniques for Production Plants (401145101)	1st semester	no semester recommended	5	0

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Mechatronics and Control Techniques for Production Plants	1st semester	no semester recommended	-	2
Exercise Mechatronics and Control Techniques for Production Plants	1st semester	no semester recommended	-	2

Module titel	Artificial Neural Networks in Structural Mechanics (Compulsory elective subject)
Identifier	4021387
Version	V1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Classical structural mechanics is based on continuum mechanics using tensor calculus, differential geometry, and modelling of inelastic material behaviour. This theoretical approach established in the 20th century is the basis for finite element programs widely used in industry and science. Innovative approaches by means of artificial neural networks are known to be very efficient to describe complex mathematical dependencies. This effect relies on the self-learning ability of neural networks to reproduce dependencies between mechanical quantities such as stresses, strains, or other state variables. However, the neural network is based on experience and has therefore tobe trained by experimental or numerical data. Once the neural network has been trained, it is able to predict structural deformations in shorter calculation times than by using classical numerical approaches. Also the accuracy does not suffer, even though that program codes of neural networks are shorter than classical finite element codes. In order to apply the new knowledge on practical examples, the students will learn how to develop a virtual copy of the engineering structure by means of a neural network. Here, a wide variety of components in the network with different layers, neurons, activation functions etc. is available and must be ordered for the application. Special attention is focused on the combination of artificial neural networks with the finite element method. Following this approach, advantages of mesh generation and equation solvers in finite element programs are used and parts of the classical mechanical models are replaced by neural networks. E.g. material models are substituted by trained neural networks leading to shorter simulation times. Due to the fact that artificial neural networks are becoming more widespread in engineering disciplines, students will be familiar with this new trend in simulation methods after visiting this course. They will gain the competences to support the development of neural network enhanced modelling and simulation in industrial and scientific applications.
Learning Objectives/ Learning Outcomes	The aim of the course is to enable students to work with artificial neural networks from the viewpoint of engineering science. This implies to understand different network topologies and their applications in structural mechanics. Classical structural models will be replaced by artificial neural networks partly or completely depending on the current problem. After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> Students: • shall understand the topology of artificial neural networks • are to gain an overview and learn motivation of network architectures (weights, bias-terms, sensilivity analysis) • are to understand different network topologies and their applications in structural mechanics • shall describe mathematical models of artificial neural networks • are to describe possible applications of artificial neural networks in structural mechanics • shall model structures enhanced by neural networks • shall program artificial neural networks

	• are to find solutions for differential equations approximated by neural networks • shall develop intelligent elements and know the processes behind neural network enhanced finite element simulatios Abilities / Skills Students: • are expected to apply artificial neural networks for numerical predictions in structural mechanics • shall program neural networks and train them by data gained from experiments or simulations • shall train artificial neural networks by means of measurement and simulation data • shall model inelastic material behaviour with artificial neural networks • are expected to apply the enhancement of finite element simulation by neural networks Competencies: Students: • shall develop intelligent elements by combining neural networks with the finite element method • are to increase the efficiency of structural calculations towards faster simulations and new structural models without material parameters trained just by experimental or simulated data • are expected to choose, depending on the current problem, whether to replace classical structural models partly or completely by artificial neural networks • shall work with artificial neural networks from the viewpoint of engineering science
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: • Mechanik I-III • Nonlinear Structural Mechanics
References	• Lecture Notes • Empfohlene weiterführende Literatur: A. Engelbrecht, Computational Intelligence, An Introduction, JohnWiley Literatur & Sens, Ltd, 2007.
Language	English
Examination Terms	An oral or a written exam
Miscellaneous	-
Module coordinator	Prof. Dr.-Ing. Marcus Stoffel
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

RWTH AACHEN UNIVERSITY

– Digital Engineering
– Elective Courses
+ Artificial Neural Networks in Structural Mechanics (4021387)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Prüfung Artificial Neural Networks in Structural Mechanics (402138701)	1st semester	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Artificial Neural Networks in Structural Mechanics	1st semester	no semester recommended	-	2
Exercise Artificial Neural Networks in Structural Mechanics	1st semester	no semester recommended	-	2

Module titel	Digital Work: Challenges and Solutions (Compulsory elective subject)
Identifier	8016720
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	• General introduction to workplace demands and job strain • Guidelines and legal background for job design • Online Risk Assessment • Circumstantial prevention (job redesign, ergonomic changes, leadership) • Behavioural prevention (recovery)
Learning Objectives/ Learning Outcomes	Overall goal: Students gain the basic knowledge about health oriented workplace design and learn to apply the acquired methods in digital job settings. After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding Students: • understand how physical and mental job demands can impact health and well-being; • know the specific risk pattern of digital workplace settings; • are familiar with methods of circumstantial and behavioural prevention. Abilities / Skills Students: • conduct and interpret a risk assessment for digital workplaces; • have learned to consider health-outcome oriented leadership styles and behaviour; • have gained skills for self-care practices. Competencies Students: • find solutions for preventing health risks at work by following the risk assessment cycle.
(Study-Specific) Prerequisites	-
(recommended) Requirements	none
References	Lecture Notes Students also receive a list of relevant literature
Language	English
Examination Terms	written or oral examination
Miscellaneous	-
Module coordinator	Modulverantworlicher: Dr.-Ing. Alexander Mertens / Universitätsprofessorin Dr. rer. soc. Jessica Lang Modulangebotsorganisator: D. Dirkes M. Sc. RWTHModellierungsteamverantwortlicher: Sebastian Otta M. A.
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	120

– Digital Engineering
– Elective Courses
+ Digital Work: Challenges and Solutions (8016720)

Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Examination: Digital Work Challenges and Solutions (801672001)	2nd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise: Digital Work Challenges and Solutions	2nd semester	no semester recommended	-	2
Lecture: Digital Work Challenges and Solutions	2nd semester	no semester recommended	-	2

– Digital Engineering
– Elective Courses
+ Laser Applications (4022685)

Module titel	Laser Applications (Compulsory elective subject)
Identifier	4022685
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2020
Valid until	-
Module level	Master
Content	• The laser principle • Properties of laser radiation (spectral, temporal and spatial) • Laser types and systems • Reflection, absorption, transmission • Temperature, heat conduction, mass diffusion and melt pool dynamics • Laser-based surface treatment • Additive Manufacturing • Joining • Cutting • Ablation • Measurement technology
Learning Objectives/ Learning Outcomes	Overall goal: Students gain basic knowledge about the generation, characteristics and applications of laser radiation. After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding: Students • understand the generation and properties of laser radiation • know the fundamentals of light-matter interaction, heat transport and phase transitions • gain knowledge about laser-based processing and manufacturing (like hardening, joining, drilling, cutting and additive manufacturing) and further fields of laser application (like measurement technology). Abilities / Skills: Students • are able to evaluate manufacturing processes in order to identify those that benefit from the use of laser radiation • can apply mathematical techniques to identify and optimise process-specific laser beam parameters. Competencies: Students • are able to identify suitable laser parameters for specific tasks in materials processing • can identify a laser source providing the desired parameters for a given process • are able to work on current research problems, e.g. within a Master’s thesis
(Study-Specific) Prerequisites	-

– Digital Engineering
– Elective Courses
+ Laser Applications (4022685)

(recommended) Requirements	none
References	Lecture notes R. Poprawe, K. Boucke, D. Hoffmann: Tailored Light 1 (Springer Verlag, 2018) R. Poprawe: Tailored Light 2 (Springer Verlag, 2011) Students receive a list of relevant literature
Language	English
Examination Terms	A written or an oral exam
Miscellaneous	-
Module coordinator	Univ.-Prof. Dr. rer. nat. Constantin Leon Häfner
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Laser Applications (402268501)	1st semester	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Laser Applications	1st semester	no semester recommended	-	2
Exercise Laser Applications	1st semester	no semester recommended	-	2

Module titel	Multibody Dynamics (Compulsory elective subject)
Identifier	4011462
Version	V1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2020
Valid until	-
Module level	Master
Content	• Introduction • Fundamentals • Fields of application • Model Building • Methods of Approach for Equivalent Models • Multi-body Systems • General mathematical description • Kinematics of Multi Body Systems • Position and Orientation of Bodies • Translational Kinematics • Rotational Kinematics • Equations of Motion • Lagrangian Equations of 2nd Kind • Newton-Euler equations • Lagrangian Equations of 1st Kind • Eigen Value Approach • Undamped non-gyroscopic systems • Damped gyroscopic systems • Eigen Value Stability Criteria Linear Systems with Harmonic Excitation • Real Frequency Matrix • Complex Frequency Matrix • State Equation • System Matrix • Eigen Value Approach • Fundamental Matrix • Modal Matrix • Theorem of Cayley-Hamilton • Analytical Solution • Numerical Solution • Step Excitation • Harmonic Excitation • Periodical Excitation Example • Modelling • Calculation • Evaluation
Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following: <u>Knowledge / Understanding:</u> Students: • shall have a profound knowledge of theory of vibrations. • shall be capable of comprehending, describing and analyzing vibratory systems.

	• shall be familiar with the most important matrix based procedures for the calculation of eigenmotions and the behaviour of linear systems under forced excitations. Abilities / Skills: Students • shall have the ability of describing mathematically any mechanical system with its inherent physical effects like elasticity, damping and friction. • shall be able to properly interpret simulation results especially under consideration of simplifications within the model compared to the real system. Competencies: Students • shall be able to derive from their knowledge the necessary methods and proceedings for the analysis and synthesis of the systems in regard. • shall be capable to solve - accessing their acquired theoretical knowledge - complex problems concerning the choice and design of industrial vibratory systems.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-none-
References	• Lecture Notes • Students also receive a list of relevant literature
Language	English
Examination Terms	Written/Oral Examination (Depending on registration numbers)
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Dr. h. c. Burkhard Corves
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Multibody Dynamics (401146201)	2nd semester	no semester recommended	5	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Tutorial Multibody Dynamics	2nd semester	no semester recommended	-	2
Lecture Multibody Dynamics	2nd semester	no semester recommended	-	2

– Digital Engineering
– Elective Courses
+ Mechanics of Engineering Materials (4011448)

Module titel	Mechanics of Engineering Materials (Compulsory elective subject)
Identifier	4011448
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2017
Valid until	-
Module level	Master
Content	The course aims at the understanding of the behaviour of engineering materials such as metals, plastics, and carbon fiber-reinforced composites. The major objective is the development and discussion of appropriate material models for elastic and inelastic materials. Further, the numerical treatment of these models will be addressed in the context of the finite element method. Finally, the according parameters will be identified by comparison with experiments. In particular, the following aspects will be addressed: • Elasticity at small and finite strains • Thermo-elasticity • Anisotropic elasticity for composites • Viscoelasticity – Creep an relaxation • Plasticity and hardening • Damage and crack initiation • Parameter identification
Learning Objectives/ Learning Outcomes	After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding Students: • know the different phenomena which can be observed in experiments; • know the different material models which have been proposed to describe these phenomena; • understand the basic concept of how to achieve an appropriate material model. Abilities / Skills Students: • analyse analytical and numerical results with respect to the quality of the adopted model; • predict the material response to a given loading scenario. Competencies Students: • critically assess the applicability and correctness of material models; • transfer theoretical models to actual engineering problems from the fields of mechanical, civil, and aeronautical engineering.
(Study-Specific) Prerequisites	-
(recommended) Requirements	-
References	Lecture Notes, AudioSlides Students also receive a list of relevant literature
Language	English
Examination Terms	A written or oral exam
Miscellaneous	-
Module coordinator	Dr.-Ing. Jaan-Willem Simon
ECTS Credits	5

– Digital Engineering
– Elective Courses
+ Mechanics of Engineering Materials (4011448)

Contact time (WSH)	3
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	45,0
Self-study hours (h)	105,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Mechanics of Engineering Materials (401144801)	2nd semester	no semester recommended	5	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Mechanics of Engineering Materials	2nd semester	no semester recommended	-	1
Lecture Mechanics of Engineering Materials	2nd semester	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

– Digital Engineering
– Elective Courses
+ Tensor Algebra and Tensor Analysis for Engineers I (4012288)

Module titel	Tensor Algebra and Tensor Analysis for Engineers I (Compulsory elective subject)
Identifier	4012288
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2009
Valid until	-
Module level	Master
Content	• Notion of the vector space • Geometrical illustration of vectors • Examples of vector spaces • Basis and dimension of the vector space • Components of a vector, summation convention • Scalar product of vectors, Euclidean space • Orthonormal basis • Dual basis • Second-order tensor as a linear mapping • Right and left mapping • Tensor product • Representation of a tensor with respect to a basis • Change of the basis, transformation rules • Special operations with second-order tensors • Tensor functions, exponential tensor function • Transposition, symmetric and skew-symmetric tensors • Inversion • Scalar product of tensors • Decomposition of second-order tensors • Vector and tensor valued functions, differential calculus • Coordinates in Euclidean space, tangent vectors • Coordinate transformation, covariant and contravariant components • Gradient, covariant derivative • Christoffel symbols, representation of the covariant derivative • Mock-Examination
Learning Objectives/ Learning Outcomes	Tensor algebra is the language of modern continuum mechanics and material theory. Due to the course the students will be able to read and understand modern scientific literature in this area, formulate and interpret tensor identities in absolute as well as index notation. The knowledge obtained within the course is also very helpful for the numerical implementation of finite element procedures.
(Study-Specific) Prerequisites	-
(recommended) Requirements	recommended: • Basic knowledge of mathematics and in particular matrix algebra
References	• Halmos, P.R. Finite-Dimensional Vector Spaces. Van Nostrand, New York, 1958. • Itskov, M. Tensor Algebra and Tensor Analysis for Engineers with Applications to Continuum Mechanics, Springer, 2007.
Language	English
Examination Terms	Written exam
Miscellaneous	-

– Digital Engineering
– Elective Courses
+ Tensor Algebra and Tensor Analysis for Engineers I (4012288)

Module coordinator	Universitätsprofessor Dr.-Ing. (RUS) Mikhail Itskov
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Examination Tensor Algebra and Tensor Analysis for Engineers I (401228801)	1st semester	no semester recommended	5	0
Exercise Tensor Algebra and Tensor Analysis for Engineers I (401228802)	1st semester	no semester recommended	0	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Vorlesung Tensor Algebra and Tensor Analysis for Engineers I	1st semester	no semester recommended	-	2

– Digital Engineering
– Elective Courses
+ Additive Manufacturing: Technologies and Processes (4017421)

Module titel	Additive Manufacturing: Technologies and Processes (Compulsory elective subject)
Identifier	4017421
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2021
Valid until	-
Module level	Master
Content	1) Introduction: motivation, market relevance, overview of relevant technologies 2) selective laser melting: process principle, develpoment of process strategies, quality and cost optimization, high power slm 3) laser metal deposition: process princlple, workflow and productivity, best practice examples 4) selective laser sintering & stereolithography: process principle, workflow and productivity, best practice examples 5) thin film processing: process principle, workflow and productivity, best practice examples 6) material & process control: material classes, properties and applications, material production and quality assurance, quality aspects within additve manufacturing, system technology and sensor technology, controlling and monitoring of laser manufacturing processes 7) design for additive manufacturing I: agil project management within additive manufacturing, extension of the CAE process chain, AM software, AM confirm product development 8) design for additive manufacturing II: simulation driven design process (topology optimization, integration of lattice structures, function integration) 9) production planning I: job preperation (data control and mesh repair, CAM (SLM vs. LMD), part placement & material handling, work safety and environment 10) production planning II: simulation (mold dynamics, heat transfer, structure, tension, protective atmosphere and gas flow, und nozzle design) 11) subsequent processes: heat treatment, surface finishing, hybrid application, automatization concepts. 12) application and market: present applications & expectet developments, efficiency, intellectual property 13) summary and future trends: key properties of AM technologie, overview of the physical and digital processchain, outlook
Learning Objectives/ Learning Outcomes	Knowledge and comprehension: - the students have knowledge of significant AM - technologies and their fundamental properties and applications - the students are in the position to differentiale AM - technotogies from conventional production processes - the students have knowledge of AM - specific construction rules and simulation driven design processes - the studends know essential pre- and post processes and interdependencies along the digital and physical process chain

	- the students know major factors of key determinants on the economic application of AM - technology - the students have knowledge of content-related aspects which correspond to present applications and expected developments Skills and competencies: - the students are able to develop own strategies and solutions to prescribed scientific issues
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: - knowledge in production technology - knowledge in heat and mass transfer - knowledge in laser technology
References	Vorlesungsskript, Übungsaufgaben
Language	German/English
Examination Terms	Exam
Miscellaneous	-
Module coordinator	Modulverantworlicher: Universitätsprofessor Dr.-Ing. Dipl.-Wirt.-Ing. Johannes Schleifenbaum
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Additive Manufacturing: Technologies and Processes (401742101)	1st semester	no semester recommended	6	0

– Digital Engineering
– Elective Courses
+ Additive Manufacturing: Technologies and Processes (4017421)

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Additive Manufacturing: Technologies and Processes	1st semester	no semester recommended	-	2
Lecture Additive Manufacturing: Technologies and Processes	1st semester	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

– Digital Engineering
– Elective Courses
+ Intelligent Monitoring of Engineering Systems (4021494)

Module titel	Intelligent Monitoring of Engineering Systems (Compulsory elective subject)
Identifier	4021494
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	The course curriculum consists of seminar lectures followed by a semester project. During the seminar lectures, the students will receive the necessary theoretical background to independently plan and execute the project in small groups. Consultation hours are offered to discuss challenges and problems arising during the course of the project. Finally, each group presents their achievements and results live and in form of a written report. The following topics are covered: • Sensing • Signal processing • Machine learning • Non-Destructive Testing (NDT) • Structural Health Monitoring (SHM) • Data pre- and postprocessing using MATLAB
Learning Objectives/ Learning Outcomes	In this course, students shall acquire the following: Knowledge / Understanding The students will understand • the theoretical foundations of structural health monitoring approaches in engineering • state-of-the-art and current trends in structural health monitoring • the fundamentals of sensors, filtering methods, and computational Intelligence Abilities / Skills The students are able to • describe and analyse mechanical engineering systems • extract and monitor relevant system parameters • apply fundamental methods of structural health monitoring • transfer their knowledge to new engineering applications in science and industry • independently plan, advance and complete projects
(Study-Specific) Prerequisites	-
(recommended) Requirements	Recommended: Programming experience, particularly in MATLAB (Python)
References	Farrar, C.R. and Worden, K., 2012. Structural Health Monitoring: A Machine Learning Perspective. Wiley.
Language	English
Examination Terms	Written or Oral Examination (100 %)

– Digital Engineering
– Elective Courses
+ Intelligent Monitoring of Engineering Systems (4021494)

Miscellaneous	-
Module coordinator	Univ.-Prof. Dr.-Ing. Bernd Markert
ECTS Credits	5
Contact time (WSH)	3
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	45,0
Self-study hours (h)	105,0

●Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Intelligent Monitoring of Engineering Sys-tems (402149401)	2nd semester	no semester recommended	5	-

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Intelligent Monitoring of Engineering Systems	2nd semester	no semester recommended	-	2
Exercise Intelligent Monitoring of Engineering Systems	2nd semester	no semester recommended	-	1

– Digital Engineering
– Elective Courses
+ Linear Control Systems (4011476)

Module titel	Linear Control Systems (Compulsory elective subject)
Identifier	4011476
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	Significance of control theory, examples of biological and biomedical control loops, functional diagrams, linearization, set up and solving of differential equations, stability, features in time domain of dynamical systems, Laplace transform, transfer function, frequency response, functional diagram algebra, features in frequency domain of dynamical systems, bode diagram, Nyquist plot, Linear control loop elements, principle and goals of controller design, algebraic stability criteria, steady state analysis and transient performance of a control loop, controller setting rules, Nyquist stability criterion, phase margin, gain margin, controller design in bode diagram.
Learning Objectives/ Learning Outcomes	After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: • know, recognize and classify the most common linear control loop elements • the effects of feedback and apply different methods to set up feedback elements (controllers) such that predefined control goals are met Abilities / Skills: • to analyze dynamical, biological and biomedical systems and identify the relevant causalities • to employ different mathematical descriptions of dynamical systems • solve differential equations by means of Laplace transform • assess of the stability of dynamical systems using different methods • obtain, interpret and employ the frequency response of dynamical systems
(Study-Specific) Prerequisites	-
(recommended) Requirements	Basic knowledge in mathematics as defined in the examination regulations.
References	-
Language	English
Examination Terms	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)
Miscellaneous	-
Module coordinator	Prof. Dr.-Ing. Heike Vallery
ECTS Credits	3

Contact time (WSH)	2
Examination duration (min)	-
Total hours (h)	90,0
Contact hours (h)	30,0
Self-study hours (h)	60,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Linear Control Systems (401147601)	1st semester	no semester recommended	3	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Linear Control Systems	1st semester	no semester recommended	-	1
Tutorial Linear Control Systems	1st semester	no semester recommended	-	1

RWTH AACHEN UNIVERSITY

– Digital Engineering
– Elective Courses
+ Optimization and Lightweighting of Structures (4011411)

Module titel	Optimization and Lightweighting of Structures (Compulsory elective subject)
Identifier	4011411
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2024
Valid until	-
Module level	Master
Content	1. Introduction to design methodology - Purposes of technical systems; Methods to derive requirements and setting up re-quirements lists - Development of technical concepts: Function structures; Discursive, heuristic and empiric methods for problem solving - Concept evaluation: Methods to evaluate and select among variants - Rules and principles of Embodiment Design - Design for X 2. Introduction to Lightweighting - Definition and general principles of lightweighting - How to compare the performance of materials? 3. Modelling and computation of loads - Statically indeterminate systems - Stresses of thin-walled structures due to transverse shear, torsion and warping-torsion 4. Modelling and computation of nonlinearities - Physical nonlinearity: Plastic bending and plastic hinge theory, composite beams - Beam theory under large deformations (Th. II. Order) 5 Stability of lightweight structures - Stability of beams - Stability of plates and shells 6. Optimization of structures - Lagrange multiplyers Topology optimization
Learning Objectives/ Learning Outcomes	Technical competencies – knowledge and skills After completing the module, students will be able to - describe and apply the product development process according to VDI 2221 along all its phases - describe methods of solution synthesis - use methods for systematic solution generation and evaluation - describe and apply the basic principles of lightweighting to create weight-optimised structural designs - calculate the load on common beam structures - comprehensively calculate the stresses in thin-walled structures - describe and model physical and geometric non-linearity in the structural response - describe stability phenomena for lightweight structures and calculate the corre-sponding structural part resistances - perform weight optimisation of load-bearing structures - analyse the structural response of lightweight structures - identify the potential for weight saving in existing structures Interdisciplinary competencies – methodic-, social-, and self-competence

– Digital Engineering
– Elective Courses
+ Optimization and Lightweighting of Structures (4011411)

	After completing the module, students will be able to - identify requirements in projects - analyse and describe technical problems - systematically find solutions to technical problems - evaluate these solutions - synthesise solution principles for technical problems
(Study-Specific) Prerequisites	-
(recommended) Requirements	Statics, elastostatics, dynamics
References	• Pahl, G. Beitz, W.: Engineering Design. Springer, 2007. • Roark, R. J., Young, W. C.: Formulas for Stress and Strain, McGraw-Hill, 1975. • Jones, R. M.: Mechanics of Composite Materials, McGraw-Hill, 1975. • Bruhn, E. F.: Analysis and Design of Flight Vehicles Structures. • Niu, M. C. Y.: Airframe Structural Design, Conmilit Press Ltd., 1988.
Language	English
Examination Terms	One written examination
Miscellaneous	-
Module coordinator	Prof. Dr.-Ing. Kai-Uwe Schröder
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	120 minutes
Total hours (h)	180,0
Contact hours (h)	60,0
Self-study hours (h)	120,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Optimization and Lightweighting of Structures (401141101)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Optimization and Lightweighting of Structures	1st semester	no semester recommended	-	2

Lecture Optimization and Lightweighting of Structures	1st semester	no semester recommended	-	2

+ Human Resource Management (8018762)

Module titel	Human Resource Management (Compulsory subject)
Identifier	8018762
Version	Kurs EMBA
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Human Resource Management In this module, concepts, practices and challenges of personnel management are analysed and discussed with the students. This includes, for example, the following topics: • Value creation, strategy and the organization: The role of HR • Employee selection, qualification and retention • Performance appraisals and careers • Compensation and benefits • Incentives and behavior of individuals and teams • Industrial and employment relations
Learning Objectives/ Learning Outcomes	Human Resource Management Students are given a deeper understanding of human resource management in organizations. They will learn concepts, models and empirical methods that can be applied to relevant HR problems. Students learn to assess the relevance and limitations of these frameworks for corporate policy. After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding Students: • understand the importance of human resource management for the company's strategy and success • know and understand the role of HRM in and for organizations • have gained a fundamental understanding of the role of the institutional environment for firms' HRM • know relevant tools, practices and processes of personnel management • understand the challenges of HR practices for individual employees and teams ; Abilities / Skills Students: • analyze and discuss the challenges of human resource management against the background of current research findings • identify the tools and processes of personnel management based on a company's objective • apply the basics of recruiting, training, development, appraisals and compensation to a workplace environment Competencies Students: • find solutions to the problems in the field of personnel management and can critically question them and compare them with alternative solutions. • apply the analytical skills to new strategic situations within organizations

+ Human Resource Management (8018762)

	• critically assess or judge the applicability of HRM approaches and instruments, taking the specific context into account
(Study-Specific) Prerequisites	-
(recommended) Requirements	None
References	Lecture Notes Students also receive a list of relevant literature
Language	German/English
Examination Terms	The final grade can be composed as follows: • Option A: Colloquium and presentation (50%) and written examination (50%,) • Option B: Colloquium and presentation (50%) and paper (50%) • Option C: Paper (50%) and written examination (50%) • Option D: Written examination (100%) or oral examination (100%) The exact form of examination (A, B, C or D) will be announced at the start of the course. Unless announced differently, option D applies.
Miscellaneous	-
Module coordinator	Univ.-Prof. Dr. rer. pol. Christine Harbring
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam: Human Resource Management (801876201)	3rd semester	no semester recommended	5	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Vorlesung: Human Resource Management	3rd semester	no semester recommended	-	2
Übung: Human Resource Management	3rd semester	no semester recommended	-	2

+ Marketing Management (8015423)

Module titel	Marketing Management (Compulsory subject)
Identifier	8015423
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2014
Valid until	-
Module level	Master
Content	- Introduction into marketing management - Focus topics: Understanding the behavior of consumers and organizations, Designing, executing, and interpreting market research, Developing a marketing strategy and a competitive positioning - Shaping market offerings through the 4P - Focus topics: Product management and design, Branding and brand architectures, Positioning and pricing,Developing communication strategies, Building distribution models - Marketing in different industries - Practical exercise: Case studies and development of own marketing strategy on the basis of real technologies/innovation
Learning Objectives/ Learning Outcomes	Overall goal: Students gain theoretical and practical knowledge in marketing as preparation for interdisciplinary leadership roles. The students have a comprehensive understanding of contemporary marketing thinking and practice. They possess a deep knowledge of theories in the fields of consumer behavior and marketing research and know how to derive a marketing strategy based on an analysis of customer needs and competitive structure. They are able to implement a marketing strategy through a systematic and coordinated use of marketing instruments (i.e., product, price, promotion, place). Furthermore, students are familiar with the unique challenges and requirements of marketing in different industries.
(Study-Specific) Prerequisites	-
(recommended) Requirements	None
References	-
Language	English
Examination Terms	One written exam
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. oec. Daniel Wentzel
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	0
Total hours (h)	150,0

+ Marketing Management (8015423)

Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Marketing Management (801542301)	2nd semester	no semester recommended	5	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Marketing Management	2nd semester	no semester recommended	-	2
Exercise Marketing Management	2nd semester	no semester recommended	-	2

+ Financial Management (8022784)

Module titel	Financial Management (Compulsory subject)
Identifier	8022784
Version	v1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2020
Valid until	-
Module level	Master
Content	Financial Management • Introduction to financial management: definitions and objectives • The transformation function of corporate financing decisions • The no-arbitrage condition and the irrelevancy theorem • Optimal leverage ratios with taxes and bankruptcy costs • The signaling function of corporate financing decisions • Agency problems of external equity financing • Agency problems of debt financing • Case study in corporate finance • Net present value maximization • Markowitz portfolio theory • Corporate valuation and the Capital Asset Pricing Model (CAPM) • Corporate valuation and taxes • Case study in corporate valuation
Learning Objectives/ Learning Outcomes	Financial Management This course aims at developing the following skills in students in an interactive class-room environment: (1) The ability to identify and classify the basic forms of financing activities. (2) The capacity to systematically describe the objectives of financing activi-ties (including ethical aspects) in terms of an overview of the functions of corporate finance identified in the literature so far. (3) The qualification to derive (and to critically question) in a qualitative as well as a quantitative way practically relevant and context-dependent recommendations for the application of different financial instruments for decisions under risk. (4) The competence to apply (and critically question) state of the art methods of firm valuation. After successfully completing this course, the students will have acquired the following learning outcomes: Knowledge / Understanding ; Students: • identify and classify the basic forms of financing activities • systematically describe the objectives of financing activities (including ethical aspects) in terms of an overview of the functions of corporate finance ; Abilities / Skills ; Students: • apply state of the art methods of firm valuation. • derive (and to critically question) in a qualitative as well as a quantitative way practically relevant and context-dependent recommendations for the application of dif-ferent financial instruments for decisions under risk. • Apply problem-solving mechanisms • Use quantitative reasoning under perfect and imperfect capital market conditions. ; ; ; Competencies Students: • critically question state of the art methods of firm valuation.

+ Financial Management (8022784)

	• derive in a qualitative as well as a quantitative way practically relevant and con-text-dependent recommendations for the application of different financial instruments for decisions under risk. • critically question recommendations for the application of different financial in-struments for decisions under risk The course approaches the first three learning goals based on the functions of financing activities and in doing so it aims at teaching basic methods and theories in finance. The fourth goal is mainly addressed by way of introducing the Fisher Model and the Capital Asset Pricing Model as the most important theoretical descriptions for a perfect capital market in equilibrium. As an overarching goal, students get acquainted with problem-solving mechanisms as well as thinking in quantitative terms under perfect and imperfect capital market conditions. ;
(Study-Specific) Prerequisites	-
(recommended) Requirements	none
References	Berk, J.B &; DeMarzo, P.M. (2019). Corporate finance (5th global ed.). Pearson Educa-tion Limited. Brealey, R. A., Myers, S. C. &; Allen, F. (2019). Principles of corporate finance (13th International ed.). New York: McGraw-Hill Education. Copeland, T. E., Weston, F. J. &; Shastri, K. (2013). Financial theory and corporate policy: Pearson new international edition (4th ed.). Pearson Education Limited.
Language	-
Examination Terms	none
Miscellaneous	-
Module coordinator	Prof. Dr. rer. pol. Wolfgang Breuer
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	70
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Examination Financial Management (802278401)	3rd semester	no semester recommended	5	-

+ Financial Management (8022784)

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Financial Management	3rd semester	no semester recommended	-	2
Excercise Financial Management	3rd semester	no semester recommended	-	2

+ Strategic Management (8025925)

Module titel	Strategic Management (Compulsory subject)
Identifier	8025925
Version	v1
Duration (Semester)	-
Cycle (Semester)	-
Valid from	Winter semester 2020
Valid until	-
Module level	Master
Content	Strategic Management ; This course provides participants with an application-oriented introduction to the process, content and context of strategic management. It has been designed to enable students to help their organization survive, drive and thrive on fundamental technological changes in their industry by making smart strategic choices grounded in rigorous strategic analysis. 1. Strategy Process: We will explore the strategy process from the setting of strategic objectives, external and internal analysis to strategy implementation and control. 2. Strategy Content: We will examine competitive and cooperative strategies as well as external, environment-oriented and internal, resource-oriented perspectives. 3. Strategy Context: We will discuss important contextual elements including the importance of ethics for strategic management. This course is likely to comprise a mixture of video lectures, flipped classroom elements, paper and case study discussions and student debates/presentations.
Learning Objectives/ Learning Outcomes	Strategic Management ; ; ; ; ; ; ; ; ; ; ; ; Overall goal: Students gain conceptual and practical knowledge about strategic management in preparation of their future leadership roles at the interface of management and technology. ; After successfully completing this course, the students will have acquired the following learning outcomes: ; Knowledge / Understanding Students: • understand key concepts and selected theories in strategic management in light of their own business experience; · ; ; ; ; ; ; ; apply important tools in strategic management intelligently based on a thorough understanding of their respective strengths and weaknesses. ;

+ Strategic Management (8025925)

	Abilities / Skills Students: · ; ; ; ; ; ; ; ; analyse and develop adequate solutions to complex strategy problems especially in times of technological transition; · ; ; ; ; ; ; ; ; make meaningful use of strategy frameworks and tools when analysing and solving strategy problems in their business context; · ; ; ; ; ; ; ; ; craft a strategy for a specific entity (e.g. corporation or business unit) and present it in a compelling manner. ; Competencies Students: · ; ; ; ; ; ; ; ; assess the economic, social and ethical implications of strategic decision options; · ; ; ; ; ; ; ; ; apply strategy concepts and tools to improve strategic planning and decision-making in their specific context; · ; ; ; ; ; ; ; ; train colleagues/team members in rigorous strategic thinking.
(Study-Specific) Prerequisites	-
(recommended) Requirements	None.
References	Gesing, J.; Antons, D.; Piening, E.; Rese, M.; Salge, T.O. (2015): Joining Forces or Going for it Alone? On the Interplay among External Collaboration Partner Types, Interfirm Governance Modes, and Internal R&;D. In: Journal of Product Innovation Management, 32(3), 424-440. Piening, E.; Salge, T.O. (2015): Understanding the Antecedents, Contingencies, and Performance Implications of Process Innovation: A Dynamic Capabilities Perspective. In: Journal of Product Innovation Management, 32(1), 424-440. Syllabus with Reading List Lecture Notes
Language	-
Examination Terms	The final grade can be composed as follows: Option A: Colloquium and presentation (50%, graded) and written examination (50%, graded, 60min.) Option B: Colloquium and presentation (50%, graded) and paper (50%, graded) Option C: Paper (50%, graded) and written examination (50%, graded, 60min.) Option D: Written examination (100%, graded, 60min.) or oral examination (100%, graded, 15-45min.) ; The exact form of examination (A, B, C or D) will be announced at the start of the course. Unless announced differently, option A applies.
Miscellaneous	-
Module coordinator	-
ECTS Credits	5

+ Strategic Management (8025925)

Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Examination Strategic Management (802592501)	3rd semester	no semester recommended	5	-

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Strategic Management	3rd semester	no semester recommended	-	2
Exercise Strategic Management	3rd semester	no semester recommended	-	2

+ International Business (8025951)

Module titel	International Business (Compulsory subject)
Identifier	8025951
Version	v1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2021
Valid until	-
Module level	Master
Content	The International Business Environment 1. Trends and Developments in the Global Economy 2. Quantitative and Empirical Foundations 3. International Trade: Causes and Consequences 4. Multinational Corporations 5. International Money and Financial Markets The International Firm 1. International Business Strategies 2. Organization of the International Firm 3. International Business in the Digital Economy 4. Foreign Market Entry Corporation, Government, and Society
Learning Objectives/ Learning Outcomes	Overall goal: Students gain a comprehensive understanding of the business environment in which international firms operate. They also gain important knowledge about economic concepts and methodologies to address strategic decisions of international corporations. After successfully completing this course, students will have acquired the following learning outcomes: Knowledge / Understanding Students: • know the “rules of the game” in the international business environment • understand international trade and the role of financial markets • are aware of major trends and developments in the global economy and can assess their business implications • identify main strategic challenges in an international context Abilities / Skills Students: • apply economic concepts and theories to international business problems • analyze economic data and extract information from various sources • formulate strategies for a range of international business scenarios Competencies Students: • structure and assess complex business problems • communicate, discuss and defend their analytical findings critically reflect on the role and responsibilities of global corporations

+ International Business (8025951)

(Study-Specific) Prerequisites	-
(recommended) Requirements	None
References	Textbooks: - ; ; Cavusgill, S.T., G. Knight and J. Riesenberger (2017). International Business: The New Realities, Pearson, 4th ed. - ; ; Krugman, P., M. Obstfeld and M. Melitz (2017). International Economics: Theory and Policy, 11th edition, Pearson. - ; ; Lasserre, P. (2018). Global Strategic Management, Palgrave, 4th ed. Various articles and cases
Language	English
Examination Terms	Written or oral examination 100%
Miscellaneous	-
Module coordinator	Prof. Dr. Thomas S. Lontzek, Prof. Dr. Oliver Lorz
ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Examination International Business (802595101)	3rd semester	no semester recommended	5	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture International Business	3rd semester	no semester recommended	-	2
Exercise International Business	3rd semester	no semester recommended	-	2

+ Finance and Accounting (8015422)

Module titel	Finance and Accounting (Compulsory subject)
Identifier	8015422
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2022
Valid until	-
Module level	Master
Content	Focus topics in financial accounting: • Structure of financial reports • Double-entry bookkeeping • Treatment of relevant events (business transactions) during the financial year • Treatment of other relevant events at the end of the financial year Focus topics in management accounting: • Introductory case study • Cost category accounting • Cost center accounting • Cost unit accounting • Application of management accounting methods in selected decision situations Focus topics in finance: • Financial objectives • Time value of money and capital budgeting • Forms of financing • Capital structure
Learning Objectives/ Learning Outcomes	Overall goal: Students gain theoretical and practical knowledge in finance and accounting as preparation for interdisciplinary leadership roles. Students learn to know essential concepts of financial accounting, management accounting and finance. In financial accounting, they obtain fundamental knowledge of financial reports and how they are derived from double-entry bookkeeping. In management accounting, the course enables students to apply decisionoriented methods of cost category, cost center and cost unit accounting. Students can apply these methods to diverse decision situations in different managerial contexts. In finance, students are introduced to financial objectives of an enterprise and their relevance for corporate decision-making. Capital budgeting methods allow students to analyze financial consequences of investment alternatives. Considerations about the capital structure of an enterprise are important to choose financing instruments in line with corporate goals.
(Study-Specific) Prerequisites	-
(recommended) Requirements	- none -
References	-
Language	English
Examination Terms	One written exam.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. pol. Peter Letmathe

+ Finance and Accounting (8015422)

ECTS Credits	5
Contact time (WSH)	4
Examination duration (min)	0
Total hours (h)	150,0
Contact hours (h)	60,0
Self-study hours (h)	90,0

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Finance and Accounting (801542201)	3rd semester	no semester recommended	5	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Finance and Accounting	3rd semester	no semester recommended	-	2
Exercise Finance and Accounting	3rd semester	no semester recommended	-	2

+ Language Course (4023298)

Module titel	Language Course (Compulsory subject)
Identifier	4023298
Version	v1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2020
Valid until	-
Module level	Master
Content	The course is aimed at students who are looking for a university-specific foreign lan-guage education, who need a foreign language for their studies and/or are planning a stay abroad (study, internship, project). Depending on the level, the range of foreign languages on offer takes into account the training of language skills specific to the profession. In the course you will learn the essential elements of grammar and vocabulary of the respective language, depending on your level, so that you can assert yourself both in writing and orally in everyday communication situations. In addition, you will learn to extract the essential information from authentic and university-specific reading and lis-tening texts as well as from various types of texts such as: Write e-mails, letters, messages and notes.
Learning Objectives/ Learning Outcomes	To learn the basics of the respective language or to deepen and expand already existing skills for active participation in everyday and working life.
(Study-Specific) Prerequisites	-
(recommended) Requirements	none
References	-
Language	German/English
Examination Terms	100% written examination in reading, listening, writing and grammar
Miscellaneous	-
Module coordinator	-
ECTS Credits	2
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	60,0
Contact hours (h)	60,0
Self-study hours (h)	,0

+ Language Course (4023298)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Language Course (402329801)	1st semester	no semester recommended	2	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Language Course	1st semester	no semester recommended	-	-
Exercise Language Course	1st semester	no semester recommended	-	-

+ Master Thesis (4014916)

Module titel	Master Thesis (Compulsory subject)
Identifier	4014916
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Completed academic paper which shall show that the students are capable of independently processing a problem related to their subject according to academic methods within a set deadline.
Learning Objectives/ Learning Outcomes	The students learn the independent approach and processing of academic themes, their documentation and written interpretation within a set deadline. They acquire systematic academic research.
(Study-Specific) Prerequisites	-
(recommended) Requirements	Die Aufgabenstellung der Masterarbeit kann erst ausgegeben werden, wenn 80 CP erreicht sind. Das Kolloquium muss spätestens 4 Wochen nach Abgabe der schriftlichen Ausarbeitung der Masterarbeit gehalten werden.
References	-
Language	English
Examination Terms	100% Master Thesis. The Participation at the Kolloquium is required.
Miscellaneous	-
Module coordinator	-
ECTS Credits	30
Contact time (WSH)	-
Examination duration (min)	-
Total hours (h)	900,0
Contact hours (h)	-
Self-study hours (h)	-

+ Master Thesis (4014916)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Master Thesis (401491601)	4th semester	no semester recommended	30	0