Anlage 1: Modulkatalog für den Masterstudiengang Computer Aided Conception and Production in Mechanical Engineering

Appendix 1: Module Catalogue for the Master's Course Computer Aided Conception and Production in Mechanical Engineering

Anlage 1 - Modulkatalog

Dieser Modulkatalog gibt den aktuellen Stand gemäß dem Tag der Beschlussfassung der Prüfungsordnung wieder, nachfolgende Änderungen, die sich nicht auf die Prüfungsformen beziehen, werden unter dem Link http://www.academy.rwth-aachen.de/de/masters bekannt gegeben.

Appendix 1 - Module Catalogue

This module catalogue provides the current status on the day the decision on the examination regulations was made; any changes that do not concern the examination forms will be announced online under: Link http://www.academy.rwth-aachen.de/de/masters

Inhaltsverzeichnis

Compulsory courses (Pflichtkurse für beide Vertiefungsrichtungen)

Module: Continuum Mechanics

MODULE TITLE: Continuum Mechanics
MODUL TITEL: Continuum Mechanics

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	5	4	Every Winter Semester	WS 2014/1015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objectives Lernziele
Continuum Mechanics • 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 • Project work: inflation of a rubber balloon, experimental study and theoretical modeling • Mock-Examination	**Continuum Mechanics** During the course students will obtain knowledge of the principles of continuum mechanics and exercise the subject matter by considering realistic problems. After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) Description of the state of strain and stress in a material body that undergoes large elastic deformations b) Calculation of strain and stress tensors c) Understanding and applying the principle of virtual work and balance equations of mechanics d) Understanding the principles of the constitutive theory <u>Abilities / Skills:</u> a) Applying material laws b) Utilization of read scientific literature on continuum mechanics. Throughout the course, the students will use and practice the modern absolute notation for tensors. Furthermore, examples based on Cartesian and curvilinear coordinates will be considered.
Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Continuum Mechanics	180	5	0
Lecture (Vorlesung) Continuum Mechanics	0	0	2
Exercise (Übung) Continuum Mechanics	0	0	2

Module: Computational Fluid Dynamics I & II

MODULE TITLE: Computational Fluid Dynamics I & II
MODUL TITEL: Computational Fluid Dynamics I & II

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	2	7	5	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Fluid Dynamics I & II • Introduction to the solution of initial value problems • Heat conduction equation • Program example • Numerical solution of the boundary-layer eqution s • Linearization of the implicit solution scheme • Program example • Introduction to the solution of linear hyperbolic equations • Numerical solution of the potential flow equation • Program example • Upwind and central discretization • Transport properties of discretizations • Dissipative and dispersive truncation errors • Introduction to the solution of the Euler equations • Integral, differential, conservative, non-conservative, and characteristic forms • Discontinuous solutions of the Euler equations • Rankine-Hugoniot relations • Introduction to upwind discretizations for the Euler equations • Derivation of the Flux-Difference Splitting scheme • Flux-Vector Splitting schemes • High-order schemes • Explicit solution schemes for the Euler equations • MacCormack, Runge-Kutta methods etc. • Convergence acceleration methods • FAS Multigrid method, local time stepping etc. • Implicit solution schemes for the Euler equations • Linearization of the non-linear equations • Dual time stepping schemes • Discretization of the Euler equations on unstructured meshes • Formulation of upwind schemes • Numerical solution of the Euler equations for the shock tube problem • Program example	**Fluid Dynamics I & II** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) Knowledge of the partial differential equations (PDE'S) of fluid mechanics b) Foundations of the discretization of PDE's c) Formulation of numerical methods for the solution of PDE's d) Understand stability and consistency of solution schemes e) Foundations of the numerical solution of Boundary Layer, Euler and Navier-Stokes equations for compressible flows f) Properties and different forms of Euler and Navier-Stokes equations g) Understand central and upwind discretization schemes for Euler and Navier-Stokes equations h) Formulation of efficient explicit and implicit solution schemes for Euler and Navier-Stokes equations <u>Abilities / Skills:</u> a) Ability to determine und understand the properties of truncation errors of numerical solution schemes b) Solution of boundary value problems with iterative solution schemes c) Implementation of solution schemes on different computer architectures d) Discussion of several examples of numerical flow simulation to understand different theoretical aspects in proactical applications e) Discretization on different mesh types Several program examples will show how the theory is applied in the numerical simulation of different flow problems

Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	**Duration of Examination (Minutes)** Prüfungsdauer (Minuten)	**Credit Points** CP	**Contact Hours** SWS
Exam (Prüfung) Computational Fluid Dynamics I	120	4	0
Lecture (Vorlesung) Computational Fluid Dynamics I	0	0	2
Exercise (Übung) Computational Fluid Dynamics I	0	0	1
Exam (Prüfung) Computational Fluid Dynamics II	90	3	0
Lecture (Vorlesung) Computational Fluid Dynamics II	0	0	1
Exercise (Übung) Computational Fluid Dynamics II	0	0	1

Module: Advanced Software Engineering

MODULE TITLE: Advanced Software Engineering
MODUL TITEL: Advanced Software Engineering

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	5	4	Every Winter Semester	WS 2014/15	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Advanced Software Engineering 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). 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. Moreover, a part of the exercise is implemented by using physical robots.	**Advanced Software Engineering** After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: a) Students comprehend for what purposes, under which conditions and with which consequences computer systems are used for the solution of problems related to Mechanical Engineering. b) Students gain solid knowledge in the Software Development Life Cycle and also the main activities and core concepts in different software development phases. Abilities / Skills: a) They 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.
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	Duration of Examination (Minutes) Prüfungsdauer (Minuten)	Credit Points CP	Contact Hours SWS
Exam (Prüfung) Advanced Software Engineering	120	5	0
Lecture (Vorlesung) Advanced oftware Engineering	0	0	2
Exercise (Übung) Advanced Software Engineering	0	0	2

Module: Simulation of Discrete Event Systems

MODULE TITLE: Simulation of Discrete Event Systems
MODUL TITEL: Simulation of Discrete Event Systems

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
3	1	5	4	Every Winter Semester	WS 2015/16	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele

Simulation of Discrete Event Systems
 	
• 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
	Simulation of Discrete Event Systems
	
	After successfully completing this course, the student will have acquired the following learning outcomes:
	
	Knowledge / Understanding:
	a) Students know important theories and techniques for modelling discrete event systems;
	b) understand the principles of simulation based on advance approaches.
	
	Abilities / Skills:
	a) Students are able to analyse real systems and build quantitative models of these systems
	b) using the proposed methods for analysis and simulation;
	c) are able to predict future states and properties of the modelled systems.
	
	Competencies:
	a) Students have learned to describe, analyse and evaluate event systems, apply their knowledge and skills to real-life engineering systems and come to well-founded conclusions;
	b) understand how to model robust, effective and efficient systems which improve the satisfaction and the safety of the persons involved.

Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	Duration of Examination (Minutes) Prüfungsdauer (Minuten)	Credit Points CP	Contact Hours SWS
Exam (Prüfung) Simulation of Discrete Event Systems	120	5	0
Lecture (Vorlesung) Simulation of Discrete Event Systems	0	0	2
Exercise (Übung) Simulation of Discrete Event Systems	0	0	2

Module: Numerical Methods in Mechanical Engineering

MODULE TITLE: Numerical Methods in Mechanical Engineering
MODUL TITEL: Numerical Methods in Mechanical Engineering

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	7	5	Every Winter Semester	WS2014/15	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Numerical Methods in Mechanical Engineering • From intuitional perception to the mathematical formulation of engineering problems; examples. Choice of assumptions and mathematical tools to formulate problems. • Classes of solution methods (overview): Analytical solutions, approximate solutions, direct approximation, approximate solution after transformation of the problem. • Classes of physical problems: discrete systems, continuous systems. Equilibrium, eigenvalue, and propagation problems. • Integral forms. • Weak formulation of problems. • The Method of Weighted Residuals (WRM). • Introduction to variational calculus. • Functionals and Functionals associated with an integral form. • The stationarity principle and 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.	**Numerical Methods in Mechanical Engineering** This course presents the theoretical background of the numerical methods commonly used in mechanical engineering. In particular, the path from the physical formulation of a problem to its mathematical formulation which is appropriate for large-scale numerical approximation methods is shown. After successfully completing this course, the students will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) Knowledge of theoretical foundations of current numerical methods in engineering. b) Knowledge to bridge between the physical formulation of a problem and a mathematical formulation suited to numerical approximation methods. c) Comprehending the individual steps and specific transformations required for approximate numerical solution. d) Choosing an appropriate approximation technique and analyzing the results obtained by various approximation methods. e) Applying acquired knowledge to develop new approximation methods. f) Critical reflection on the consistency and correctness of numerical methods. <u>Abilities / Skills:</u> a) Applying variational methods to obtain equivalent formulations of a problem of differential equations. b) Constructing basis functions compatible with the boundary conditions. c) Constructing and applying a variety of approximation methods based on the WRM (collocation by points, collocation by subdomains, Galerkin's method, least squares method, Ritz method) d) Solving constrained optimization problems by using the Lagrange Multipliers Method. e) Constructing the associated energy potential and applying the stationarity principle for a conservative mechanical problem. f) Applying tools of numerical integration.

Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Numerical Methods in Mechanical Engineering	150	7	0
Lecture (Vorlesung) Numerical Methods in Mechanical Engineering	0	0	3
Practical Session (Praktikum) Numerical Methods in Mechanical Engineering	0	0	2

Module: Multibody Dynamics

MODULE TITLE: Multibody Dynamics **MODUL TITEL: Multibody Dynamics**						
GENERAL INFORMATION **ALLGEMEINE ANGABEN**						
Term **Fachsemester**	**Duration** **Dauer**	**Credit Points** **Kreditpunkte**	**Contact Hour** **SWS**	**Frequency** **Häufigkeit**	**Start** **Turnus Start**	**Language** **Sprache**
2	1	5	4	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content **Inhalt**	**Educational Objektives** **Lernziele**
Multibody Dynamics • Introduction • Fundamentals • Fields of application • Model Building • Methods of Approach for Equivalent Models • Multi-body Systems • Determination of the Model Parameters • 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 • Linearisation • 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 Introduction of Multi Body Simulation Software • ADAMS • SIMPACK • SimMechanics	**Multibody Dynamics** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) The students have a profound knowledge of theory of vibrations. b) The students are capable of comprehending, describing and analyzing vibratory systems. c) The students are familiar with the most important matrix based procedures for the calculation of eigenmotions and the behavior of linear systems under forced excitations. d) For the calculation of nonlinear system the students can select suitable program systems and carry out proper simulations. <u>Abilities / Skills:</u> a) The students have the ability of describing mathematically any mechanical system with its inherent physical effects like elasticity, damping and friction. b) The students are able to properly interpret simulation results especially under consideration of simplifications within the model compared to the real system. <u>Competencies:</u> a) The students are able to derive from their knowledge the necessary methods and proceedings for the analysis and synthesis of the systems in regard. Thus they are capable to solve - accessing their acquired theoretical knowledge - complex problems concerning the choice and design of industrial vibratory systems.

Hands-On-Laboratory for Multi Body Simulation Software • ADAMS • SIMPACK • SimMechanics Example • Modelling • Determination of Parameters • Calculation • Evaluation	
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Multibody Dynamics	120	5	0
Lecture (Vorlesung) Multibody Dynamics	0	0	2
Exercise (Übung) Multibody Dynamics	0	0	2

Module: Finite Element Methods for Engineers

MODULE TITLE: Finite Element Methods for Engineers
MODUL TITEL: Finite Element Methods for Engineers

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	5	4	Every Winter Semester	WS 2010/2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objectives Lernziele
Finite Element Methods for Engineers • General introduction, concept of the finite element method • Symbolic assembly procedure • 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. • Two-dimensional problems of elasticity, triangular element, plain strain and plane stress problems • Torsion of a prismatic bar • Examples for plain strain and plane stress problems discretized by linear triangular elements • Axisymmetric stress analysis, 3-D stress analysis • Revision course	**Finite Element Methods for Engineers** The aim of the course is to impart the elementary knowledge about finite element methods and their application to solid and structural mechanics. After successfully completing this course, the student will have acquired the following learning outcomes. The students will <u>Knowledge / Understanding:</u> a) understand why the FE-Method and the other numerical methods behind are important for engineering practice b) understand the concept of FEM c) be able to find solutions for truss systems under various boundary conditions d) understand the concepts of variational calculus e) be able to find solutions for mechanical problems by using weighted residual methods f) be able to use finite element method for plane strain, plane stress and torsion problems

Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Finite Element Methods for Engineers	120	5	0
Lecture (Vorlesung) Finite Element Methods for Engineers	0	0	2
Exercise (Übung) Finite Element Methods for Engineers	0	0	2

Compulsory courses conception of machines (Pflichtbereich Conception of Machines)

Module: Nonlinear Structural Mechanics

MODULE TITLE: Nonlinear Structural Mechanics
MODUL TITEL: Nonlinear Structural Mechanics

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	5	4	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Nonlinear Structural Mechanics • 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	**Nonlinear Structural Mechanics** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) The students know the important steps and features of consistent modeling of 2-D and 1-D structures for linear and nonlinear static and dynamic analysis. b) They know the criteria how to assess 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. <u>Abilities / Skills:</u> a) The students are able to analyse static and dynamic simulation results with respect to the quality of the adopted structural model. b) The students can 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). <u>Competencies:</u>. a) The students are able to critically assess the applicability, consistency and correctness of structural models. b) The students are able to use their obtained knowledge in order to develop new theoretical models in the sense of a generalization.

• 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	
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Nonlinear Structural Mechanics	120	5	0
Lecture (Vorlesung) Nonlinear Structural Mechanics	0	0	2
Exercise (Übung) Nonlinear Structural Mechanics	0	0	2

Module: Failure of Structures and Structural Elements

MODULE TITLE: Failure of Structures and Structural Elements
MODUL TITEL: Failure of Structures and Structural Elements

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	5	3	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content
Inhalt

Failure of Structures and Structural Elements

- 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

Educational Objectives
Lernziele

Failure of Structures and Structural Elements

After successfully completing this course, the student will have acquired the following learning outcomes:

Knowledge / Understanding:

a) Knowledge about the physical effects leading to failure of structures and mechanical systems:
   - excessive elastic deformations,
   - buckling of load carrying elements,
   - permanent plastic deformations,
   - material damage,
   - initiation and propagation of cracks.

b) Predictions by means of limit and shakedown theories, failure of structures and mechanical systems under monotonic and cyclic loads and determination of corresponding load-carrying capacities.

c) Modelling the phenomenon of fracture and determination of critical loads for crack propagation

d) Knowledge about the most important types of failure and description of their occurrence with respect to functional requirements of mechanical elements.

Abilities / Skills:

e) Determination of limit loads for structures

f) Modelling the phenomenon of fracture and determine critical loads for crack propagation

g) Transfer theoretical and mathematical models to actual engineering problems and implementation into design codes

h) State-of-the-art numerical methods for the use of failure criteria in applied mechanical engineering.

Exercises are integrated in the lecture so that students work individually or in groups on practical examples.

Requirements
Voraussetzungen

-none-

Grading / Form of Examination
Benotung / Prüfungsform

The module grading is weighted according to the CP-allocation

- Written Exam (schriftliche Prüfung) or
- Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Failure of Structures and Structural Elements	120	5	0
Lecture (Vorlesung) Failure of Structures and Structural Elements	0	0	2
Exercise (Übung) Failure of Structures and Structural Elements	0	0	1

Module: Machine Design Process and Practical Applications of Computer- Aided Engineering Tools

MODULE TITLE: Machine Design Process and Practical Applications of Computer- Aided Engineering Tools

MODUL TITEL: Machine Design Process and Practical Applications of Computer- Aided Engineering Tools

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
3	1	7	5	Every Winter Semester	WS 2015/16	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Machine Design Process and Practical Applications of Computer- Aided Engineering Tools Topic: Introduction Topic: Drawing Standards I • Projection drawing and axonometric views • Elements of technical drawings • Dimensioning Topic: Drawing Standards II • Section views • Broken views Topic: Joins and Connections • Connection types • Bolted connections • Shaft and hub connections Topic: Geometrical Irregularities and Tolerances • Dimension tolerances • Form and position tolerances • Technical surfaces Topic: Bearing of Shafts • Bearing principles • Bearing arrangements • Seals Topic: Power Transmission • Definitions and principles • Technical representation • Examples Topic: Engineering Design Process, Requirements List • Introduction to design methodology • General process of engineering design • Requirements list	**Machine Design Process and Practical Applications of Computer- Aided Engineering Tools** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> Students a) know the most common machine elements and applicable design rules, standards and understand production drawings including dimensions and tolerances. b) know structured problem solving strategies, esp. the engineering design process acc. to VDI 2221. c) know the structure and some examples of the body of design rules d) know the functionality of parametric 3D CAD software as well as the common modelling techniques and the workflow to produce part and assembly models and drawings. <u>Abilities / Skills:</u> a) Students are able to operate commercial 3D CAD software and apply the common modelling techniques to produce part and assembly models and drawings. <u>Competencies</u>: Students a) are able to analyse and design mechanical systems using common machine elements through the ability to read and understand as well as draft assembly drawings according to ISO drawing standards and define the production specifications on machined parts through the ability of drafting production drawings according to ISO drawing standards. b) are able to identify possible restrictions on a design task and to develop and select applicable concept solutions with a systematic approach. c) are able to assess the applicability of design rules depending on effective design restrictions. Rules of embodiment design, design principles and guidelines are applied to draw up technical drafts.

Topic: Conceptual Design I • Function structures and principle solutions • Design catalogues • Heuristic and analogy methods Topic: Conceptual Design II • Systematic variation, classification schemes • Overall solutions: morphological matrix Topic: Design Rules I - Essential Rules • Introduction to design rules • Essential rules ´simple´ and ´clear´ • Essential rules ´safe´ Topic: Design Rules II - Principles • Principles of fault-free design, force transmission, stability and bi-stability, self-help, division of tasks • Topic: Design Rules III - Guidelines / DFX • Selected examples: design for assembly and production... Topic: Parametric 3D CAD • Part Modelling • Assembly modelling • Drafting	
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Machine Design Process and Practical Applications of Computer- Aided Engineering Tools	150	7	0
Lecture (Vorlesung) Machine Design Process and Practical Applications of Computer- Aided Engineering Tools	0	0	2
Exercise (Übung) Machine Design Process and Practical Applications of Computer- Aided Engineering Tools	0	0	2
Practical Session (Praktikum) Machine Design Process and Practical Applications of Computer- Aided Engineering Tools	0	0	1

Compulory courses production (Pflichtbereich Production)

Module: Simulation Techniques (Modelling and Simulation) in Manufacturing Technology

MODULE TITLE: Simulation Techniques (Modelling and Simulation) in Manufacturing Technology
MODUL TITEL: Simulation Techniques (Modelling and Simulation) in Manufacturing Technology

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
3	1	5	3	Every Winter Semester	WS 2015/16	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Simulation Techniques(Modelling and Simulation) in Manufacturing Technology • In the first lecture an introduction into the subject simulation techniques in manufacturing technology is given. • The contents of the second lecture are the fundamental aspects and processes in metal forming, particular bulk forming. • After the student have learned the fundamental aspect of metal forming, in this lecture the focus are the actual simulation techniques in metal forming. • The forth lecture deals about the fundamental aspects and the simulation of sheet metal forming. • In lecture no. 5 an introduction to the fundamentals and the simulation techniques in blanking and fine blanking processes is given. • The contents of the sixth lecture are the principles of cutting processes. • The lecture no. 7 gives a general overview about the different cutting processes. • One method in modelling cutting processes is the usage of Finite Element Modelling (FEM). This lecture shows different current examples for the FE simulation of cutting processes. • Lecture gives an introduction to cutting with undefined cutting edges. • The focus of lecture no. 10 is the presentation of actual modelling methods in grinding. • Special emphasis in lecture no. 11 will be placed on Rapid Prototyping, Rapid Tooling and Virtual Reality. • The content of the last lecture deals about the design of process chains and technology planning.	**Simulation Techniques(Modelling and Simulation) in Manufacturing Technology** In the last years, the simulation of manufacturing processes has developed to an essential tool for planning and improving processes. In almost every kind of manufacturing process (e.g. forming, cutting, grinding etc.) the simulation assists the engineer in designing, optimising and controlling processes as well as designing of equipment or just to understand and predict fundamental mechanisms. After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> Students a) the basic methods in modelling and simulation of selective manufacturing processes. b) overview of the main applicability's of simulation techniques in the following manufacturing and planning processes: • Forming processes • Fine blanking • Sheet metal forming • Cutting processes • Grinding • Process chains • Virtual Reality • Rapid Prototyping. c) the understanding of manufacturing processes is a basic requirement in setting up models. Therefore the lecture provides the basics of manufacturing technologies, subsequent the modelling of these processes is an objective of this lecture.

	Abilities / Skills: d) to use commercial software like DEFORM2D and DEFORM3D. In small groups the participants work with this software supported by students who already gained experience in handling this software.
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Modelling and Simulation in Manufacturing Technology	120	5	0
Lecture (Vorlesung) Modelling and Simulation in Manufacturing Technology	0	0	2
Exercise (Übung) Modelling and Simulation in Manufacturing Technology	0	0	1

Module: Quality Management

MODULE TITLE: QUALITY MANAGEMENT
MODUL TITEL: QUALITY MANAGEMENT

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
3	1	5	4	Every Winter Semester	WS 2015/2016	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content
Inhalt

Quality Management

01 Introduction:
- The concept of quality, Quality Management structures, poor quality and defects, Deming-Chain, quality improvement and failure prevention

02 Normative QM Systems:
- Total Quality Management (TQM), normative quality management standards, implementation of quality management systems, auditing and certification concepts

03 Strategic Quality Programs:
- Strategic Quality Programs, EFQM, RADAR, Six Sigma, Sigma Levels, ACQMM (Aachener QM Modell) , Quality Stream (Statistics in the exercise)

04 Quality and Economics:
- Quality controlling, quality cost accounting, cost-related process performance, cost-related quality performance indicators, balanced scorecard, target costing

05 QM in Field Data Evaluation:
- Field Data analysis, Weibull-Analysis, Isochron-Diagram, MIS-Diagram

06 QM in Manufacturing:
- Statistical Process Control, 5S, Value Stream Mapping

07 QM in the Early Phases - Focus Product:
- Kano-Model, Quality Function Deployment (QFD), House of Quality, TRIZ

08 QM in the Early Phases - Focus Process:
- Process Optimization , Design of Experiments (DoE), Factorial Designs, Shainin Methodology

09 QM in the Early Phases - Deviation:
- Design Review, Quality Assessment, Fault Tree Analysis, FMEA, DRBFM, Rapid Quality Deployment

10 QM in the Procurement:
- Procurement Strategies, supplier selection, incoming inspection, accepted quality level

11 Quality and Information:
- Quality control loops, quality data basis, Computer Aided Quality Management (CAQ), computer-aided test planning, implementation of CAQ systems

12 QM in Service Industries:
- Service Engineering, Service Level Agreement, Service Blueprinting, ServQual, Vignette Techniques, Service FMEA, Conjoint Analyses

Educational Objektives
Lernziele

Quality Management Due to the growing importance of quality assurance in industrial production and economy, the lecture "Quality Management" was initiated at the Faculty of Production Engineering.

Quality issues of industrial applications and necessary underlying theories are emphasized during the course of this lecture. It is the main aim of this lecture to present the students with the abstract concept of *quality*, its importance and social relevance, possible organizational forms of quality systems and relating quality management methods and tools.

During the turn, a broader perspective can also be given via discussions about more advanced and detailed topics such as strategic quality planning, balancing quality costs and quality related legal questions.

After successfully completing this course, the student will have acquired the following learning outcomes:

Knowledge / Understanding: The students…
- a) understand the abstract concept of quality;
- b) know the standards (norms);
- c) understand main quality issues of industrial applications;
- d) know necessary underlying management theories;
- e) understand essential quality tools, their function, the benefit and their interdependence;
- f) know the organization of management systems;
- g) know the organization of quality systems

Abilities / Skills: The students…
- a) have deepen their statistic knowledge;
- b) have improved their computer skills;
- c) have improved their economic thinking;
- d) analyse problematic quality issues:
- e) apply tools to contexts

Competencies: The students…
- a) critically assess topics such as quality planning, quality costs and quality legal questions via discussions;
- b) critically reflect approaches, methods and guiding principles while communicating their opinions

Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	**Duration of Examination (Minutes)** Prüfungsdauer (Minuten)	**Credit Points** CP	**Contact Hours** SWS
Exam (Prüfung) Quality Management	120	5	0
Lecture (Vorlesung) Quality Management	0	0	2
Exercise (Übung) Quality Management	0	0	2

Module: Production Management A

MODULE TITLE: PRODUCTION MANAGEMENT A **MODUL TITEL: PRODUCTION MANAGEMENT A**						
GENERAL INFORMATION **ALLGEMEINE ANGABEN**						
Term **Fachsemester**	**Duration** **Dauer**	**Credit Points** **Kreditpunkte**	**Contact Hour** **SWS**	**Frequency** **Häufigkeit**	**Start** **Turnus Start**	**Language** **Sprache**
3	1	5	4	Every Winter Semester	WS 2015/2016	English

CONTENT DETAILS **INHALTLICHE ANGABEN**	
Content **Inhalt**	**Educational Objektives** **Lernziele**
Production Management A • From Taylorism To Virtual Factory • Production Strategies • Business and Process Modelling • Product Planning & Engineering • Variant Management • Structured Innovation Process • Process Planning • Planning for Manufacture & Assembly • Operations Management • Materials Management • Lean Production - Production Systems • Technology Management I • Technology Management II	**Production Management A** 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 will gain knowledge which topics have to be considered in this context and how the gained knowledge can be transferred to daily business of a company. For the purposes of manufacturing engineering, Students know the following tasks that have to be carried out. After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: a) know and follow the problems of producing companies; Abilities / Skills: a) apply this knowledge to elaborate possibilities for rationalization and automation issues; b) able to analyze problems in all enterprise domains which are involved in the manufacturing process Competencies: a) have the ability to elaborate rationalization methods and tools b) 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 superior domains cost accounting, E.D.P., overall organization
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
None	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Production Management A	90	5	0
Lecture (Vorlesung) Production Management A	0	0	2
Exercise (Übung) Production Management A	0	0	2

Electives courses (Wahlbereich für beide Vertiefungsrichtungen)

Module: Practical Introduction to FEM-Software I

MODULE TITLE: Practical Introduction to FEM-Software I
MODUL TITEL: Practical Introduction to FEM-Software I

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	**Duration** Dauer	**Credit Points** Kreditpunkte	**Contact Hour** SWS	**Frequency** Häufigkeit	**Start** Turnus Start	**Language** Sprache
1	1	3	3	Every Winter Semester	WS 2014/15	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	**Educational Objectives** Lernziele
Practical Introduction to FEM-Software I • General introduction, structure of the FEM program • ANSYS (GUI) • Modeling and calculation of truss structures with ANSYS. • Modeling beam structures • ANSYS commands, working with input files • Post processing for beam elements • General introduction to the FEM program CACULIX • Modeling and calculating beam structures with CALULIX • Data exchange between ANSYS <-> CALCULIX. • Introduction to 2D solid modeling in ANSYS (part 1) • Types of plane elements, free mesh, boundary conditions, mesh size, post processing • Commands for 2D Problems in CALCULIX • Data exchange between ANSYS <-> CALCULIX • Boundary conditions, mesh size, post processing • Introduction to 2D solid modeling in ANSYS (part 2) • Mapped mesh, bottom up / top down approach • ANSYS commands, heat transfer problems • APDL, element types, boundary conditions, h- and p-method. • Post processing, error estimation. • ANSYS 3D modeling (part 1), creating the geometry, selecting and grouping commands. • 3D modeling (part 2), ANSYS and CALCULIX commands, 3D element types. • 3D modeling (part 3), ANSYS and CALCULIX commands, extrusion of 2D Models. • Project work, modeling • Project work, modeling, solving, post processing • Project work, documentation, report • Revision course	**Practical Introduction to FEM-Software I** The aim of the course is to give an overview of the possibilities and an introduction to the use of FEM software. After successfully completing this course, the student will have acquired the following learning outcomes: The students will <u>Knowledge / Understanding:</u> a) have sufficient knowledge of ANSYS and CALCULIX b) obtain a practical feeling how to deal with FE programs c) understand the concept of solid modeling and automatic meshing d) understand the commands to create input-files e) know how to define boundary conditions and loads <u>Abilities / Skills:</u> f) be able to create 2D/3D FE models g) be able to solve typical linear structural and heat transfer problems h) be able to validate FE models and analyze errors i) to write a project report

Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Practical Introduction to FEM-Software I	120	3	0
Lecture (Vorlesung) Practical Introduction to FEM-Software I	0	0	1
Practical Session (Praktikum) Practical Introduction to FEM-Software I	0	0	2

Module: Practical Introduction to FEM-Software II

MODULE TITLE: Practical Introduction to FEM-Software II
MODUL TITEL: Practical Introduction to FEM-Software II

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	3	3	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objectives Lernziele
Practical Introduction to FEM-Software II • Time depending Problems, multi load steps, sub modeling. • Sub modeling • Non-linear Material, Plasticity • Non-linear Material, rubber-like materials, viscoelastic • Composite materials. • Solver for non-linear problems. • Contact problems part 1, coupling and constraint equations. • Contact problems part 2, CAD-Import. • Harmonic response • Modal analysis • Death and birth option, harmonic response. • Multiphysics problems 1, heat transfer, voltage. • Multiphysics problems 2, heat radiation. • Revision course	**Practical Introduction to FEM-Software II** In part II of the course the considered examples are extended to nonlinear problems and applications. After successfully completing this course, the student will have acquired the following learning outcomes: The students will Knowledge / Understanding: a) obtain an overview about various kinds of FE calculations. b) get understanding of the difficulties concerned with nonlinear calculations. Abilities / Skills: a) be able to calculate nonlinear problems with ANSYS and CALCULIX.
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
Recommended: Practical Introduction to FEM-Software I	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	Duration of Examination (Minutes) Prüfungsdauer (Minuten)	Credit Points CP	Contact Hours SWS
Exam (Prüfung) Practical Introduction to FEM-Software II	120	3	0
Lecture (Vorlesung) Practical Introduction to FEM-Software II	0	0	1
Practical Session (Prakfikum) Practical Introduction to FEM-Software II	0	0	2

Module: Finite Element Methods in Lightweight Design

MODULE TITLE: Finite Element Methods in Lightweight Design
MODUL TITEL: Finite Element Methods in Lightweight Design

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	5	3	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content
Inhalt

Finite Element Methods in Lightweight Design

- Recapitulation of the principles of the Finite Elements Method
- Limitation of elements
- Selection criteria
- Pre/Postprocessing
- meshing, incompatible meshes
- Isoparametric element family
- Numerical integration schemes
- Numerical Integrating schemes
- Element locking
- Reduced integration to avoid locking
- Dynamic problems
- Introduction and fundamental equations
- Finite element formulation
- Eigenvalue problems
- Integration in the time domain (implicit and explicit)
- Modal superposition
- Condensation techniques
- substructure
- static condensation
- dynamic condensation
- Introduction to nonlinear analysis
- Geometric nonlinearities
- Material nonlinarities
- Iteration procedures
- Stability behaviour of structures
- Fundamental equations
- Linear stability analysis
- Introduction to contact problems
- Finite Elements procedures
- Introduction to crash and impact
- Integration schemes
- Hourglass oscillation
- Energy balance
- Element deletion techniques
- Strain-rate dependent material behavior

Educational Objektives
Lernziele

Finite Element Methods in Lightweight Design

After successfully completing this course, the student will have acquired the following learning outcomes:

Knowledge and Understanding:
Students

a) know the mechanical and mathematical relations used in the Finite Element Method.

b) understand the structural problems to be solved and the underlying fundamentals of the solution methods that are provided by commercial codes.

Abilities / Skills:

Students

a) are able to apply the Finite Element Method properly in order to achieve reliable numerical results for linear structural problems.

b) are able to analyse the Finite Element models according to the desired field of application, taking the assumptions of solution methods into account.

Competencies:

Students

a) have learned to work with commercial codes and to find those solutions from the software handbook that are suited best for the investigated structural problem.

b) are able to interpret the achieved numerical results and evaluate their correctness.

Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Finite Element Methods in Lightweight Design	120	5	0
Lecture (Vorlesung) Finite Element Methods in Lightweight Design	0	0	2
Exercise (Übung) Finite Element Methods in Lightweight Design	0	0	1

Module: Micro- and Macrosimulation of Casting Processes

MODULE TITLE: Micro- and Macrosimulation of Casting Processes
MODUL TITEL: Micro- and Macrosimulation of Casting Processes

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	**Duration** Dauer	**Credit Points** Kreditpunkte	**Contact Hour** SWS	**Frequency** Häufigkeit	**Start** Turnus Start	**Language** Sprache
1	1	4	3	Every Winter Semester	WS 2014/15	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	**Educational Objektives** Lernziele
Micro- and Macrosimulation of Casting Processes General overview • transport phenomena in solidification processes • conservation equations for a solid-liquid mixture • discretization of the transport phenomena • FV and FE methods, hybrid FE-CV method, • upwind schemes • Transient thermal simulation of casting processes • Modelling of phase changes • 3-D net radiation method • industrial applications • Process optimization and calibration • definition of an optimization problem: objective function, constraints • application: optimization of the Brigdman investment casting process of turbine blades • calibration of the mould/cast heat transfer coefficient • Thermomechanical analysis (I) • nonlinear material models (elastoplasticity, viscoplasticity) • finite element discretization • modelling of the coherent mushy zone • Thermomechanical analysis(II) • heat transfer model function of gap or contact • master/slave contact algorithm • industrial applications • Mould filling simulation • Equations and fluid flow properties • surface capturing/tracking methods (e.g. VOF) • industrial applications • Introduction to microsimulation • phenomena of microstructure evolution • thermodynamic calculation of phase diagrams • kinetics of nucleation • cellular automaton versus phase field method • Phase field theory (I) • thermodynamical background • motion driven by mean curvature • Phase field theory (II): thermal dendrites • moving free boundary problem • dendritic growth modes (Ivantsov solution) • coupling to temperature • industrial applications	**Micro- and Macrosimulation of Casting Processes** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) Thermal and thermomechanical simulation of casting processes, b) Casting processes (investment, chill, high pressure die, gravity, …) c) Numerical methods for latent heat release during solidification, for radiation exchange d) Phase field approach to predict microstructure formation e) Free surface in mold filling f) High temperature behavior of materials, mainly the unknown mushy state <u>Abilities / Skills:</u> a) to select an appropriate numerical scheme for the simulation of solidification processes (thermal, thermomechanical and mould filling analysis) b) to specify the correct boundary conditions for a thermal and/or mechanical analysis of a casting process, e. g. to choose the appropriate radiation B.C: either with free surface radiation or with view factors c) to analyse the results (cooling curve, stress-strain evolution) of the macro-simulation of the considered casting process d) to set-up a transient nonlinear thermomechanical analysis with mould/metal interaction e) to understand the evolution of different microstructures during cooling processes <u>Competencies:</u> a) For a specific casting process, identification of the most relevant transport phenomena to be modelled b) Modification of a thermal and/or thermo-mechanical analysis model for another casting process. c) Knowledge about different dendritic growth morphologies occurring during solidification and modelled via the phase-field approach.

• Phase field theory (III) • coupling to solute diffusion • coupling to fluid flow • multicomponent phase field model • Macrosimulation tutorial with CASTS • sand casting of steel lever • Bridgman casting of a cluster of three single-crystal turbine blades • Microsimulation tutorial with MICRESS • eutectic solidification • equiaxed dendritic solidification	
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
• Basic knowledge in numerical methods (e.g. finite element method) • Basic knowledge in materials science and continuum mechanics • Conservation equations • Numerical methods to solve systems of PDEs • Notion of thermodynamics (e.g. phase diagrams)	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Micro- and Macrosimulation of Casting Processes	120	4	0
Lecture (Vorlesung) Micro- and Macrosimulation of Casting Processes	0	0	2
Exercise (Übung) Micro- and Macrosimulation of Casting Processes	0	0	1

Module: Welding and Joining Technologies

MODULE TITLE: WELDING AND JOINING TECHNOLOGIES
MODUL TITEL: WELDING AND JOINTING TECHNOLOGIES

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	**Duration** Dauer	**Credit Points** Kreditpunkte	**Contact Hour** SWS	**Frequency** Häufigkeit	**Start** Turnus Start	**Language** Sprache
2	1	5	4	Every Summer Semester	SS2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	**Educational Objektives** Lernziele
Welding and Joining Technologies - Introduction - Welding of steel - Gas Fusion Welding - Manual Metal Arc Welding - Submerged Arc Welding - TIG Welding - Plasma Welding - MIG Welding - Electro Gas Welding - Electro Slag Welding - Pressure Welding - Resistance Welding - Electron Beam Welding - Laser Beam Welding - Special Processes - Mechanisation / Automation - Sensor Technology - Brazing - Mechanical Joining / Adhesive Bonding - Essentials in Design and Calculation	**Welding and Joining Technologies** Welding is an interdisciplinary technology. All fields of industrial manufacturing require the joining of individual parts to functional groups. Many welding and cutting technologies are applicable for this purpose. After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: a) know and understand the main welding technologies Abilities / Skills: b) capable to select the suitable welding technologies for a welding task and to substantiate the selection by specifying the advantages and the disadvantages of the individual methods

Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
None	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	**Duration of Examination (Minutes)** Prüfungsdauer (Minuten)	**Credit Points** CP	**Contact Hours** SWS
Exam (Prüfung) Welding and Joining Technologies	120	5	0
Lecture (Vorlesung) Welding and Joining Technologies		0	2
Exercise (Übung) Welding and Joining Technologies		0	2

Module: Modelling, Model Reduction and Simulation in Laser Processing I

MODULE TITLE: Modeling, Model Reduction and Simulation in Laser Processing I
MODUL TITEL: Modeling, Model Reduction and Simulation in Laser Processing I

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	5	4	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Modeling, Model Reduction and Simulation in Laser Processing I Overview of contents, definition of the 10 learning targets • the contribution of the engineer to the interactive co-operation of scientific disciplines • main features of the theory of cognition (Karl Popper) • laser radiation, Helmholtz equation, reduced model: SVE-approximation • Learning target 1: gaussian beam, beam guiding and forming • reflection, transmission and absorption of light • Learning target 2: reduced model of the Fresnel Formulae for the limiting case of small discplacement current, optical parameters • technical task and examples: cutting with laser radiation • Learning target 3: quality features of the high quality cut • physical task of cutting and identification of quality defined processing domains • Learning target 4: relation of physical phenomena to the built up of quality degradations • technical task and examples: drilling with laser radiation • physical task and 5 dominant phenomena • Learning target 5: quality features of the drilled hole • mathematical modelling Ia: time scales • degrees of freedom in phase space of dependent variables • separation of time scales in simple dynamical systems • Learning target 6a: separation of time scales • mathematical modelling Ib: length scales • thermal boundary layer in heat conduction with moving boundaries • Learning target 6b: separation of length scales • mathematical modelling IIa: Free Boundary Problems (FBP) for the solid phase • reduced model for the FBP : motion of the melting front, integral methods, variational formulation • Learning target 7: heating and melting phase of ablation	**Modeling, Model Reduction and Simulation in Laser Processing I** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) Free Boundary Problems and integral methods of solution b) Non-linear stability analysis using spectral methods c) Analysis of the structural stability of model equations d) Knowledge about at least 3 types of laser systems, temporal and spatial distribution of laser radiation, Fresnel-number, invariant quantity of light propagation e) Understanding the structure of solution for the Helmholtz-equation, diffraction, 5 parameter pairs of optical material equations, transmission, reflection, absorption, Fresnel Formulae, polarisation of matter and radiation f) Knowing and understanding the 5 different, dominant phenomena of drilling, welding and cutting with laser radiation g) Knowledge about the physical meaning of the terms contained in the Navier-Stokes equations for mass, momentum, and energy balance h) Knowledge about the main properties of the solution in the asymptotic case of thin film flow (boundary layer) i) Knowledge about the effect of dissipation in distributed dynamical systems (inertial manifold) and about examples for the application of methods for the reduction of the dimension in dissipative systems j) Understanding and performing the separation of length and time scales in simple systems k) Understand the interactive cooperation of scientists from engineering, physics and mathematics for application of model based methods for diagnosis in laser processing

• mathematical modelling IIb: FBP for the liquid phase • Navier-Stokes equations, material equations and boundary values • mathematical model reduction: melt flow • reduced model for thin film flow • Learning target 8: boundary character, integral and spectral methods • model reduction and solution with controlled error: melt flow at low Reynolds-number • structural stability of the reduced model: lubrication approximation, fingering and droplet formation • Learning target 9: creeping flow and expansion with respect to the Reynolds-number, exact solution of a model problem for arbitrary Reynolds-number • global properties of the solution of balance equations for mass, momentum and thermal energy • Learning target 10: scales for the choice of processing parameters in cutting and drilling • concluding discussion of the learning targets • actual research and development of laser processing	Abilities / Skills: a) Application of model based methods for solving practical tasks from discussion of project examples b) Application of 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
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Modeling, Model Reduction and Simulation in Laser Processing I	120	5	0
Lecture (Vorlesung) Modeling, Model Reduction and Simulation in Laser Processing I	0	0	2
Exercise (Übung) Modeling, Model Reduction and Simulation in Laser Processing I	0	0	2

Module: Mechatronics and Control Techniques for Production Plants

MODULE TITLE: MECHATRONICS AND CONTROL TECHNIQUES FOR PRODUCTION PLANTS

MODUL TITEL: MECHATRONICS AND CONTROL TECHNIQUES FOR PRODUCTION PLANTS

GENERAL INFORMATION

ALLGEMEINE ANGABEN

Term Fachsemester	**Duration** Dauer	**Credit Points** Kreditpunkte	**Contact Hour** SWS	**Frequency** Häufigkeit	**Start** Turnus Start	**Language** Sprache
1	1	5	4	Every Winter Semester	WS 2014/2015	English

CONTENT DETAILS

INHALTLICHE ANGABEN

Content Inhalt	**Educational Objektives** Lernziele
Mechatronics and Control Techniques for Production Plants Introduction to Mechatronics and control for production - Overview of mechatronic systems - Construction of feed drives Information processing in mechatronic systems - Theory and examples of embedded systems - Programmable logic circuits Measurement systems and sensors - Position and angle measuring systems - Acceleration and vibration measurement Mechanical control - Single and multi-spindle turning machines - Further developments Gripping technology - Gripping principles - Sensor technology and applications Position control of feed drives - Control concept of a machine axis - Accuracy and synchronous control of multi-axis Numerical Control 1: structure, programming, CAM - Construction of NC controls - NC programming process Numerical Control 2: Interpolation - Kinematic transformations and compensations - Interpolation Industrial robots and handling systems, robot control - Structure and kinematic transformations - RC programming Programmable Logic Control (PLC) and motion control (MC) - Fundaments of information Processing - Programmable Controllers Signal processing, process and condition monitoring - Tasks of process and condition monitoring - Use of sensors and signal processing	**Mechatronics and Control Techniques for Production Plants** Students get familiar with the structure, the design and the engineering process of mechatronic systems. After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) understand the characteristics of the behavior and control of feed axes in machine tools; b) know different types of sensors and their application within machine tools <u>Abilities / Skills:</u> a) apply this knowledge to create control programs in different programming tools b) get to know the essential features and applications of logical, numerical and motion controls of machines

Mechatronic Engineering, Simulation environments for virtual commissioning - Essentials of modeling of mechatronic systems - Behavior modeling and data management - Introduction: complexity of software and systems	
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
Recommended: Machine Tools	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Mechatronics and Control Techniques For Production Plants	120	5	0
Lecture (Vorlesung) Mechatronics and Control Techniques For Production Plants	0	0	2
Exercise (Übung) Mechatronics and Control Techniques For Production Plants	0	0	2

Electives courses conception (Wahlbereich Conception of Machines)

Module: Fundamentals of Light Weight Design

MODULE TITLE: Fundamentals of Lightweight Design
MODUL TITEL: Fundamentals of Lightweight Design

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	4	3	Every Winter Semester	WS 2014/15	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele

Fundamentals of Lightweight Design
 	
• Introduction to Lightweight Design
• Motivation, definitions, concepts
• Special aspects of light structures
• Materials used in Lightweight Design
• Equations of continuum mechanics
• Idealization of structures
• Equilibrium conditions
  o Statically determined support of 2-dim and 3-dim structures
  o Determination of external and internal forces
• 2-dim and 3-dim truss type structures
  o General equations
  o Design concepts
• Beams loaded in bending and shear
  o General equations
• Differential equation of shear rigid beams
• Matrix formulations: transfer matrix, stiffness matrix
• Shear flexible beam
• Shear deformation
• Shear flow in thin walled beams
  o Open cross section
  o Closed cross section
  o Shear center
• Plastic bending
  o Combined normal and bending load
• Torsion of beams (St. Venants Torsion)
  o Solid sections
  o Closed thin walled sections
  o Open thin walled sections
  o Bending Torsion
• Introduction to shear web theory
• Open and closed section beams
• 2-dim shear web structures
• rectangular, parallelogram, trapezoidal and general 4node webs
• 3-dim shear web structures
	Fundamentals of Lightweight Design
	
	After successfully completing this course, the student will have acquired the following learning outcomes:
	
	<u>Knowledge and Understanding:</u>
	Students
	a) know methods to pre-design lightweight structures for various loading and boundary conditions.
	b) understand the conception of structure idealisation and analytical calculation tools in lightweight structural design.
	
	<u>Abilities / Skills:</u>
	Students
	a) are able to calculate stresses and deformations ofthin-walled lightweight structures and to design them properly, taking into account the appropriate idealisation as well as the assumptions of the theory.
	b) are able to analyse lightweight structures according to their desired field of application.
	
	<u>Competencies:</u>
	Students
	a) have learned to solve structural problems by application of engineering approaches.
	b) are able to assess the validity of results of numerical simulation software.
	c) are able to evaluate existing structural concepts, develop ideas for improvements and communicate their results.

Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	**Duration of Examination (Minutes)** Prüfungsdauer (Minuten)	**Credit Points** CP	**Contact Hours** SWS
Exam (Prüfung) Fundamentals of Lightweight Design	120	4	0
Lecture (Vorlesung) Fundamentals of Lightweight Design	0	0	2
Exercise (Übung) Fundamentals of Lightweight Design	0	0	1

Module: Tensor Algebra and Tensor Analysis for Engineering Students I

MODULE TITLE: Tensor Algebra and Tensor Analysis for Engineering Students I
MODUL TITEL: Tensor Algebra and Tensor Analysis for Engineering Students I

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	**Duration** Dauer	**Credit Points** Kreditpunkte	**Contact Hour** SWS	**Frequency** Häufigkeit	**Start** Turnus Start	**Language** Sprache
1	1	5	4	Every Winter Semester	WS 2014/15	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	**Educational Objectives** Lernziele
Tensor Algebra and Tensor Analysis for Engineering Students I • 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 t • 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	**Tensor Algebra and Tensor Analysis for Engineering Students I** Tensor algebra is the language of modern continuum mechanics and material theory. After successfully completing this course, the student will have acquired the following learning outcomes: The students will Knowledge / Understanding: a) be able to read and understand modern scientific literature in this area, formulate and interpret tensor identities in absolute as well as index notation. b) understand principles of differential geometry and field theory The students will Abilities / Skills: a) be able to apply field operators
Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Tensor Algebra and Tensor Analysis for Engineers I	120	5	0
Lecture (Vorlesung) Tensor Algebra and Tensor Analysis for Engineers I	0	0	2
Exercise (Übung) Tensor Algebra and Tensor Analysis for Engineers I	0	0	2

Module: Tensor Algebra and Tensor Analysis for Engineering Students II

MODULE TITLE: Tensor Algebra and Tensor Analysis for Engineering Students II
MODUL TITEL: Tensor Algebra and Tensor Analysis for Engineering Students II

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	**Duration** Dauer	**Credit Points** Kreditpunkte	**Contact Hour** SWS	**Frequency** Häufigkeit	**Start** Turnus Start	**Language** Sprache
2	1	5	4	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	**Educational Objektives** Lernziele
Tensor Algebra and Tensor Analysis for Engineering Students II • Three-dimensional vector fields • Divergence and curl • Eigenvalue problem for second-order tensors • Eigenvalues and eigenvectors • Characteristic polynomial • Principal invariants of a second-order tensor • Relationships between principal invariants, principal traces and eigenvalues • Spectral representation and eigenprojections • Spectral decomposition of symmetric tensors • Cayley-Hamilton theorem • Scalar-valued isotropic tensor functions • Representations of isotropic tensor functions • Scalar-valued anisotropic tensor functions • Rychlewski´s theorem • Material symmetry • Isotropic, transversely isotropic and orthotropic materials • Derivatives of scalar-valued tensor functions • Tensor differentiation rules • Derivatives of principal invariants, principal traces and eigenvalues of a second-order tensor • Constitutive relations for hyperelastic materials • Tensor-valued isotropic tensor functions • Representation theorem • Example: constitutive relations for isotropic and anisotropic elastic materials • Mock-Examination	**Tensor Algebra and Tensor Analysis for Engineering Students II** Additionally to the results of the first part of the course, the students obtain the following learning outcomes: The students will Knowledge / Understanding: a) acquire knowledge of material symmetry. Abilities / Skills: a) be able to formulate constitutive relations for isotropic and anisotropic materials like fiber-reinforced composites or soft biological tissues b) be able to formulate various balance equations for solids and fluids in absolute and index notation on the basis of the field theory and differential calculus
Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
Recommended: Tensor Algebra and Tensor Analysis for Engineers I	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Tensor Algebra and Tensor Analysis for Engineers II	120	5	0
Lecture (Vorlesung) Tensor Algebra and Tensor Analysis for Engineers II	0	0	2
Exercise (Übung) Tensor Algebra and Tensor Analysis for Engineers II	0	0	2

Electives courses production (Wahlbereich Production)

Module: Machine Tools

MODULE TITLE: MACHINE TOOLS
MODUL TITEL: MACHINE TOOLS

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	5	4	Every Winter Semester	WS 2014/2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Machine Tools • L1: An introduction to the machine tool design and machine tools for forming • E1: Metal-forming machines • L2: Metal-cutting machines with geometrically defined and undefined cutting edges • E2: Tour around the shop floor of WZL and IPT • L3: Design of mounts and mount components with respect to the static behavior • E3: Design of structural components and software tools for the design of machine tools • L4: Finite-Element-Analysis, Multi- Body- Simulation, Machine Foundations • E4: Finite-Element-Analysis • L5: Hydrodynamic, hydrostatic and aerostatic bearings and guidance systems • E5: Calculation of hydrostatic sildeways • L6: Linear guidance systems, ball screws, bearings, spindle bearing systems, seals and covers • E6: Guideways, Bearings, Spindle Bearing Systems, Ball Screws, Seals • L7: Measuring instruments, geometric and kinematic behavior of machine tools • E7: Geometrical, static and thermal characteristics of machine tools • L8: Metrological investigation of the static and dynamic behavior of machine tools,acoustic behavior of machine tools • E8: Principles of Noise Measurement and Rating • L9: Metrological analysis of the dynamic behavior of machine tools • E9: Metrological analysis of the dynamic behavior of machine tools • L10: Drives and inverters • E10: Drives • L11: Structure of Feed Drives, Mechanical Components of Feed Drives, Position Measuring Systems and Control Systems • E11: Layout of the mechanical components of feed drives • L12: Programmable logic controllers, numerical controls, NC programming • E12: Manual programming of machine tools	**Machine Tools** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) know the most important types of production machinery, and understand their properties and their most relevant parameters as well as the general context <u>Abilities / Skills:</u> a) able to determine and calculate the corresponding mechanical and electrical properties; b) apply this knowledge and able to transfer calculation procedures to related topics

Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
None	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	**Duration of Examination (Minutes)** Prüfungsdauer (Minuten)	**Credit Points** CP	**Contact Hours** SWS
Exam (Prüfung) Machine Tools	120	5	0
Lecture (Vorlesung) Machine Tools	0	0	2
Exercise (Übung) Machine Tools	0	0	2

Module: Manufacturing Technology I

MODULE TITLE: Manufacturing Technology I
MODUL TITEL: Manufacturing Technology I

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	5	4	Every Winter Semester	WS 2014/2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Manufacturing Technology I • Introduction to manufacturing technology • Measuring and testing in manufacturing technology • Principles of machining with geometrically defined cutting edges • Cutting criteria • Cutting materials, tools and lubricants • Applications of processes with defined cutting edge • Principles of cutting with undefined cutting edges • Grinding tools and grinding wheel preparation • Applications of processes with undefined cutting edge • Material removal manufacturing processes (EDM, ECM) • Laser and high pressure water jet machining • Additive manufacturing (RP, RT)	**Manufacturing Technology I** After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: Students a) get an overview on manufacturing technologies. They know and understand the principles of cutting, forming, material removal and additive manufacturing. b) know and understand process parameters, cutting and forming criteria, tool and workpiece characteristics. Abilities / Skills: Students a) apply this knowledge and are able to choose the right manufacturing processes with regard to geometrical and functional workpiece properties. b) are able to estimate the effects of process parameter variations on forces, tool life, wear mechanisms and rim zone characteristics. Competences: Students a) critically analyse company decisions with technological background and communicate the assessments to non-specialist audiences. b) optimize manufacturing processes and assess possible consequences on part functionality.
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
None	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	Duration of Examination (Minutes) Prüfungsdauer (Minuten)	Credit Points CP	Contact Hours SWS
Exam (Prüfung) Manufacturing Technology I	90	5	0
Lecture (Vorlesung) Manufacturing Technology I	0	0	2
Exercise (Übung) Manufacturing Technology I	0	0	2

Modul: Manufacturing Technology II

MODULE TITLE: Manufacturing Technology II
MODUL TITEL: Manufacturing Technology II

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	5	4	Every Summer Semester	WS 2014/2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Manufacturing Technology II • Metal-based Materials • Tool Materials • Powder Metallurgy • Tribology • Near Surface Damages and Functional Surfaces • High-Speed Machining • Bulk and Sheet Metal Forming • Computer-aided Technology Planning • Hybrid Manufacturing Methods • Productivity and Profitability • Manufacturing of Optical Components • Manufacturing of Components for Mobility • Manufacturing Methods for Toolmaking	**Manufacturing Technology II** After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: Students c) get a deeper understanding in technologically comprehensive topics like material science and tribology. d) know and understand the mechanisms to improve the performance of powder metallurgical, cutting, forming and hybrid processes. Abilities / Skills: Students c) apply this knowledge and are able to assess manufacturing processes with regard to near surface damages and functional surfaces. d) are able to evaluate processes by calculation of key figures for productivity, profitability and reliability. Competences: Students c) critically analyze company decisions with technological background and communicate the assessments to non-specialist audiences. d) are familiar with the latest trends in seminal branches like optical components, mobility and toolmaking.
Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
Recommended: Manufacturing Technology I	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	Duration of Examination (Minutes) Prüfungsdauer (Minuten)	Credit Points CP	Contact Hours SWS
Exam (Prüfung) Manufacturing Technology II	90	5	0
Lecture (Vorlesung) Manufacturing Technology II	0	0	2
Exercise (Übung) Manufacturing Technology II	0	0	2

Module: Production Metrology

MODULE TITLE: Production Metrology
MODUL TITEL: Production Metrology

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
2	1	5	4	Every Summer Semester	SS 2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Production Metrology Introduction • Relevance of metrology for quality assurance and its integration in production processes. Metrological principles • Metrological concepts and definitions (Calibration, Uncertainty etc.) Tolerancing • Form and positional tolerances, tolerancing principles and fundamentals Inspection Planning • Tasks and workflow of inspection planning, Procedure for creation of inspection plans Shop floor measuring devices/ Measuring sensors • Commonly used manual inspection devices for the shop floor, Function and application of inductive, capacitive and pneumatical sensors Optoelectronic inspection devices • Optical inspection systems for geometry testing and applications Form and surface inspection devices • Tactile and optical system for the characterisation of forms and surfaces, surfaces parameters Coordinate measurement technology • Principles, types and applications of coordinate measuring machines Gauging inspection • Form and positional gauging, Gauging Procedures Statistical fundamentals • Statistical parameters for the description of production and • measuring processes, tests on normal distribution	**Production Metrology** The aim of this lecture is to create the awareness, that “measuring” comprehends a lot more than plain data acquisition and that metrology is a vital part of modern production processes. After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: Students a) know the function and the responsibility of metrology for production b) know the theoretical essentials which have to be taken into consideration while the measuring process is planned, controlled, analysed, are discussed c) know current measuring principles and devices in the field of industrial production d) know statistical essentials being necessary for analysis of the measured values Abilities / Skills: Students a) are able to define measuring task on the basis of given features b) are able to select adequate measuring devices for measuring tasks c) are able to interpret measuring results Competencies: Students a) can make their decision (having arguments) on using metrology within production b) have learned to make decisions concerning measurement on the base of different parameters

SPC, Process Capability • Statistical analysis and control of processes, Process capability indices Inspection device management • Tasks and procedures of inspection device management, Calculation of measuring device capability, Calibration chain	
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Production Metrology	120	5	0
Lecture (Vorlesung) Production Metrology	0	0	2
Exercise (Übung) Production Metrology	0	0	2

Module: Industrial Engineering

MODULE TITLE: INDUSTRIAL ENGINEERING
MODUL TITEL: INDUSTRIAL ENGINEERING

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	5	4	Every Winter Semester	WS 2014/2015	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Industrial Engineering Work as a Scientific Field of Research • Fundamentals of industrial engineering • Trends and challenges in the field of industrial engineering Industrial Organization and Work Organization • Classification of industrial organization and work organization in modern industries • Modelling options of structure organization and process organization • Principles of function and object oriented order processing • Traditional industrial organizations and trends • Methods of activity planning and scheduling Work Organization within Direct and Indirect Departments • The phenomenon ''organization'' • Charateristics of direct and indirect departments • Types of work organization in direct and indirect departments Work and Time Study I • The operational purpose of time data • REFA types of activities and REFA types of times • Methods for the determination of time data • The REFA Stop Watch Time Study method and the work sampling method Work and Time Study II • The principles of the sequence-analytic time modelling (predetermined motion-time systems) • Application of MTM (,,Methods Time Measurement'') Ergonomic Design and Usability Engineering • Design criteria and requirements of ergonomic design • Anthropometric design • Methods for the analysis of movement-, sight- and reaching-areas • Computer aided design and evaluation aids Computer and Office Work • Conventional and modern components of a computer workstation • Overview of display technologies • Aspects of work psychology • Risk assessment for computer work stations • Office concepts	**Industrial Engineering** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) know and understand the essentials of work science covering technical, organizational and personnel aspects. <u>Abilities / Skills:</u> a) able to interpret respective work situations, predict consequences and future work system states <u>Competencies:</u> a) able to independently scrutinize and discuss the proposed methods and theories and also judge their applicability. b) by using the methods students are able to analyze work systems according to various practical problems. c) able to apply the theoretical models, methodologies and practical techniques to problem solution and work system design in modern enterprises

Ergonomic Work Place Design in Production Areas • Different types of physical and muscular work • Factors influencing spine damage • Methods for assessing the danger of spine damage at work places • Physiological principles of work place design Occupational Risk Prevention (ORP) • Effects of occupational safety for the company and national economy • Terms of safety science • Technical, organizational and personal measures of occupational risk prevention Work Ecology - Noise and Hazardous Substances • Physical and psychological measurement categories of sound • Noise induced hearing damages • Organizational and personal noise control • Taxonomy and effects of hazardous substances Work Ecology II - Illumination • Physical and physiological essentials of illumination • Effects of lighting on work performance and health • Measurement of light • Relevance of illumination for workplace design Remuneration and Motivation • Forms of remuneration • Relationship between remuneration and motivation • Approaches to job evaluation Interorganziational Cooperation and Suitable Information • Technological (IT) Support • Terms of network technology • Software tools for the support of coordination, cooperation and communication • Effects of the technology on enterprises and employees • Forms of organizations and conditions suitable for the use of network technology	
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
None	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) Industrial Engineering	120	5	0
Lecture (Vorlesung) Vorlesung Industrial Engineering	0	0	2
Exercise (Übung) Übung Industrial Engineering	0	0	2

Module: Control Engineering

MODULE TITLE: Control Engineering
MODUL TITEL: Control Engineering

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	2	2	Every Winter Semester	WS 2014/15	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Control Engineering 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.	**Control Engineering** After successfully completing this course, the student will have acquired the following learning outcomes: Knowledge / Understanding: a) know, recognize and classify the most common linear control loop elements b) the effects of feedback and apply different methods to set up feedback elements (controllers) such that predefined control goals are met Abilities / Skills: a) to analyze dynamical, biological and biomedical systems and identify the relevant causalities b) to employ different mathematical descriptions of dynamical systems c) to solve differential equations by means of Laplace transform d) to assess of the stability of dynamical systems by using different methods e) to obtain, interpret and employ the frequency response of dynamical systems
Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
Basic knowledge in mathematics as defined in the examination regulations.	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	Duration of Examination (Minutes) Prüfungsdauer (Minuten)	Credit Points CP	Contact Hours SWS
Exam (Prüfung) Control Engineering	120	2	0
Lecture (Vorlesung) Control Engineering	0	0	1
Exercise (Übung) Control Engineering	0	0	1

Compulsory non-technical (Zusatzbereich beider Vertiefungsrichtungen)

Modul: German Language Course

MODULE TITLE: German Language Course
MODUL TITEL: Deutschkurs

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
1	1	6	4	Every Winter Semester	WS 2014/15	German

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
German Language Course • Getting to know someone • Introducing oneself • City explorations • Orientation in the city • Techniques: learning and remembering words • Buying groceries • Communication on the phone • Techniques: learning grammar systematically • Calendar, festivities • Holidays • Learning and forgetting • Learning psychology • German newspapers • Reading habits • When in Rome, do as the Romans do • Intercultural experience • Media • Geographic German studies • Inventions and progress • Between cultures • Environmental protection/problems • Project Europe • Job market Germany • Applications • CVs	**German Language Course** After successfully completing this course, the student will have acquired the following learning outcomes: <u>Knowledge / Understanding:</u> a) Knowledge on German Culture and Cultural Studies; b) Qualification to accomplish everyday communication within university surroundings (dormitory, cafeteria etc.) c) Understanding cultural situations at German universities <u>Abilities / Skills:</u> a) Prerequisites for culturally adequate application documents for internships (CV, letter of motivation);
Requirements Voraussetzungen	**Grading / Form of Examination** Benotung / Prüfungsform
-none-	The module grading is weighted according to the CP-allocation • Written Exam (schriftliche Prüfung) or • Oral Exam (mündliche Prüfung)

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Exam (Prüfung) German Language Course	200	6	0
Lecture (Vorlesung)	0	0	2
Exercise (Übung) German Language Course	0	0	2

Modul: Industrial Internship

MODULE TITLE: Industrial Internship **MODUL TITEL: Industrial Internship**						
GENERAL INFORMATION **ALLGEMEINE ANGABEN**						
Term **Fachsemester**	**Duration** **Dauer**	**Credit Points** **Kreditpunkte**	**Contact Hour** **SWS**	**Frequency** **Häufigkeit**	**Start** **Turnus Start**	**Language** **Sprache**
4	9 weeks	9	-	Every Summer Semester	SS 2016	English

CONTENT DETAILS **INHALTLICHE ANGABEN**	
Content **Inhalt**	**Educational Objektives** **Lernziele**
See Guidelines for Practical Work Experience	See Guidelines for Practical Work Experience
Requirements **Voraussetzungen**	**Grading / Form of Examination** **Benotung / Prüfungsform**
-none-	-none-

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Report (Bericht), Colloquium	-	9	0

Modul: Mini Thesis

MODULE TITLE: Mini Thesis **MODUL TITEL: Mini Thesis**						
GENERAL INFORMATION **ALLGEMEINE ANGABEN**						
Term **Fachsemester**	**Duration** **Dauer**	**Credit Points** **Kreditpunkte**	**Contact Hour** **SWS**	**Frequency** **Häufigkeit**	**Start** **Turnus Start**	**Language** **Sprache**
3	260 h	9	-	Every Winter Semester	WS 2015/2016	English

CONTENT DETAILS **INHALTLICHE ANGABEN**	
Content **Inhalt**	**Educational Objektives** **Lernziele**
Mini Thesis Completed academic paper, which is written under supervision. The students work out an outline with their tutors, determine partial tasks and aids and also appoint the required amount of time necessary for fulfilling the task.	**Mini Thesis** The students learn the approach and processing of academic themes, their documentation and written interpretation under intensive supervision. They acquire the methodology of systematic academic research.
Requirements **Voraussetzungen**	**Grading** **Benotung**
-none-	The module grading is weighted according to the CP-allocation • Mini-Thesis (written paper, 40-70 pages)

TEACHING METHODS / COURSES & EXAMINATIONS **LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN**			
Title **Titel**	**Duration of Examination (Minutes)** **Prüfungsdauer (Minuten)**	**Credit Points** **CP**	**Contact Hours** **SWS**
Mini Thesis	260h	9	0

Modul: Master Thesis

MODULE TITLE: MASTER THESIS - RWTH
MODUL TITEL: MASTERARBEIT

GENERAL INFORMATION
ALLGEMEINE ANGABEN

Term Fachsemester	Duration Dauer	Credit Points Kreditpunkte	Contact Hour SWS	Frequency Häufigkeit	Start Turnus Start	Language Sprache
4	4 months	20	-	Every Summer Semester	SS 2016	English

CONTENT DETAILS
INHALTLICHE ANGABEN

Content Inhalt	Educational Objektives Lernziele
Master Thesis 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.	**Master Thesis** 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.
Requirements Voraussetzungen	**Grading** Benotung
- Industrial internship - Mini Thesis - Minimum 92 ECTS	• The grade will be formed from the arithmetical average according to § 9 (1) of the examination regulations.

TEACHING METHODS / COURSES & EXAMINATIONS
LEHRFORMEN / VERANSTALTUNGEN & ZUGEHÖRIGE PRÜFUNGEN

Title Titel	Duration of Examination (Minutes) Prüfungsdauer (Minuten)	Credit Points CP	Contact Hours SWS
Master Thesis (Masterarbeit)	80 Pages	20	0
Master Thesis Colloquium (Masterarbeitskolloquium)	30 Min.		0