PADERBORN UNIVERSITY

FACULTY OF MECHANICAL ENGINEERING

MODULE MANUAL
MASTER'S DEGREE PROGRAMME IN ADDITIVE MANUFACTURING
V1

DATE: 15. JANUAR 2026

Preamble to the module manual of the Master`s degree programme in Additive Manufacturing V1

Programme structure for the master`s degree programme in *Additive Manufacturing*

<table>
<tr><td rowspan="4">Semester</td><td>4</td><td colspan="4">Master`s Thesis 25 LP</td></tr>
<tr><td>3</td><td rowspan="3">10 Pflichtmodule 51 CP</td><td rowspan="3">4 Technical elective modules 20 CP</td><td rowspan="3">Industrial Internship 12 CP</td><td rowspan="3">Research paper 12 CP</td></tr>
<tr><td>2</td></tr>
<tr><td>1</td></tr>
</table>

The following types of courses are offered:

Lecture: The lecture serves as an introduction to the subject and the systematic transfer of knowledge in the form of lectures.
Exercise: In the exercise, the material of a subject is deepened and explained using examples and practiced independently by the students.
Seminar: In a seminar, students and lecturers work together to develop, expand and deepen a sub-area of a subject or several subjects.
Practical Training: Practical courses serve to deepen the knowledge imparted through experiments.

Programme structure for the master`s degree programme in Additive Manufacturing:

Module	CP	Sem. 1	Sem. 2	Sem. 3	Sem. 4
		Workload / h			
Plastics Technologies in Additive Manufacturing	5	150			
Materials Science of Metals	5	150			
3D-Metal Printing	5	150			
Introduction to Additive Manufacturing & Manufacturing Technology	6	180			
Materials Science of Plastics	5	150			
Powder Technology	5	150			
Structure Optimization	5		150		
Design Rules for Additive Manufacturing	5		150		
Product Creation	5		150		
Standard Software Application Development	5			150	
Technical elective module 1	5		150		
Technical elective module 2	5			150	
Technical elective module 3	5			150	
Technical elective module 4	5				150
Industrial Internship	12		360		
Research Paper	12			360	
Master`s Thesis	25				750
Total Workload / h		**930**	**960**	**810**	**900**
Total CP	**120**	**31**	**32**	**27**	**30**

4 technical elective modules must be selected from the following list:

Technical elective modules
Tooling Technology – Planning, Manufacture, Postprocessing
Design for Additive Manufacturing
3D-Printing of Ceramics
Experimental Methods
Computer Aided Alloy Design
Visualization and Industry 4.0
Additive Consulting
Mechanics of Plastics
Recycling of Plastics

Inhaltsverzeichnis

1 List of abbreviations

C:	compulsory (P Pflicht)
CE:	compulsory elective (WP Wahlpflicht)
CP:	Credit points in ECTS (1 CP corresponds to a workload of 30 h)
de:	german
en:	english
Ex:	Exercise
h:	hours
L:	Lecture
MAP:	final module exam
min	minutes
MP:	module exam
MTP:	partial module exam
P:	practical course
QT:	qualified participation (Qualifizierte Teilnahme)
S:	seminar
Sem.:	Semester
SL:	academic achievement (Studienleistung)
SS:	summer term
T:	Tutorial
TN:	Participants (Teilnehmer)
WS:	winter term

2 Compulsory modules

<table>
<tr><th colspan="5">NEU25 Plastics Technologies in Additive Manufacturing</th></tr>
<tr><td colspan="5">Plastics Technologies in Additive Manufacturing</td></tr>
<tr><td>Module number:
M.104.6170</td><td>Workload (h):
150</td><td>Credits:
5</td><td colspan="2">Regular Cycle:
winter term</td></tr>
<tr><td>Language:
en</td><td>Semester number:
1.</td><td>Duration (in sem.):
1</td><td colspan="2">Module status (P=C/WP=CE)
P</td></tr>
<tr><td>1</td><td colspan="4">Module structure:
<table>
<tr><th></th><th>Course</th><th>form of teachin</th><th>contact-time (h)</th><th>self-study (h)</th><th>status (C/CE)</th><th>group size (TN)</th></tr>
<tr><td>a)</td><td>L.104.42215
Plastics Technologies in Additive Manufacturing</td><td>L2
Ex2</td><td>60</td><td>90</td><td>C</td><td>40</td></tr>
</table></td></tr>
<tr><td>2</td><td colspan="4">Options within the module:
None</td></tr>
<tr><td>3</td><td colspan="4">Admission requirements:
none</td></tr>
<tr><td>4</td><td colspan="4">Contents:

• Fused Deposition Modeling (FDM)
• Plastic Freeforming (PF)
• Variable Nozzle Fused Granular Fabrication (VFGF)
• Selective Laser Sintering (SLS)
• MultiJet Fusion (MJF)
• Material qualification
• Processability of different plastics
• High temperature plastics
• Highly filled plastics
• Mechanical properties
• Post-processing</td></tr>
</table>

5	**Learning outcomes and competences:** After attending the course, they will be able to choose a suitable plastic additive manufacturing technology for their application under consideration of the basic processability of different materials (high temperature, semi-crystalline, amorphous, highly filled). Also, the students will be able to assess the achievable mechanical properties of additively manufactured components and decide on an appropriate post-processing option.
6	**Assessments:** ☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)

zu	**Type of examination**	**Duration or scope**	**Weighting for the module grade**
a)	written or oral examination	90 - 120 minutes or 45 - 60 minutes	100%

7	**Study Achievement:** none
8	**Prerequisites for participation in examinations:** None
9	**Prerequisites for assigning credits:** The credit points are awarded after the module examination (MAP) was passed.
10	**Weighting for overall grade:** The module is weighted according to the number of credits (factor 1).
11	**Reuse in degree courses or degree course versions :** Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4
12	**Module coordinator:** Prof. Dr.-Ing. Elmar Moritzer
13	**Additional Notes:** None

NEU25 Materials Science of Metals

Materials Science of Metals

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.6171	150	5	winter term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	1.	1	P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.23275 Materials Science of Metals	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

None

4 **Contents:**

- Fundamentals of materials testing
- solidification
- additive manufacturing
- crystalline and amorphous structure of metals
- lattice defects
- microstructure
- mechanical properties
- alloy theory
- changes in the state of pure metals
- steel
- steel production
- non-ferrous metals
- recovery and recrystallization behavior
- fundamentals of heat treatment

5 **Learning outcomes and competences:**

Students acquire knowledge about the structure of metals, in particular the relationship between the microstructure and the resulting mechanical properties. They also acquire the ability to find a suitable method for influencing the microstructures to set the desired mechanical properties and knowledge of the test methods for characterizing these component properties.

<table>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)
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</table></td></tr>
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<tr><td>12</td><td>Module coordinator:
Prof. Dr. Mirko Schaper</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 3D-Metal Printing

3D-Metal Printing

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.6172	150	5	winter term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	1.	1	P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.25235 3D-Metal Printing	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

No special requirements, but basic knowledge of materials science and production technology is an advantage.

4 **Contents:**

This module provides a comprehensive introduction to machine and process-side metallic 3D printing technology. Students acquire in-depth knowledge of the process chain of various metallic 3D printing processes such as selective laser melting (SLM) and directed energy deposition (DED) in order to develop a sound understanding of their areas of application and modes of operation. Another important point is the selection of the right material for the processes. Here, not only criteria such as material properties and compatibility are taken into account, but also their environmental balance and recyclability, and evaluated in the context of process stability, component quality and costs in order to ensure optimal and sustainable results in terms of quality and application. In addition to presenting the physical process chain of 3D metal printing, the event will also focus on the digital image of the process. The presentation and application of defined methods for modelling and optimizing 3D printing processes is another important aspect of the module. Students will be able to create complex components and optimize printing processes taking into account various parameters and ecological aspects in order to achieve efficient and precise results. Students will be able to create complex components and optimize printing processes taking into account various parameters and ecological aspects in order to achieve efficient and precise results. Students will then acquire skills in defect detection and quality control for metal 3D printed parts and processes. Practical exercises will enable them to identify potential sources of errors and develop strategies to guarantee and ensure print quality. Process advantages as well as process limitations can thus be worked out and understood. Students also have the opportunity to analyze case studies and current developments in the metal 3D printing industry. In particular, cost-benefit considerations, the ecological efficiency of 3D printing processes compared to conventional methods and the possibilities of sustainable production are emphasized. further investigations are necessary to unfold the full potential of flake laminates for molding and other processes.

5	**Learning outcomes and competences:** • Understanding of the machine and process principles of metallic 3D printing technology. • Knowledge of the various 3D metal printing processes (SLM, DED, . . .) • Ability to select suitable metal materials for 3D printing. • Application in the field of modelling and optimization of metallic 3D printing processes. • Acquire skills in defect detection and quality control of metal 3D printed parts. • Analyze case studies and current developments in the metal 3D printing industry. • Ability to evaluate and implement circular value chains in material selection, process design and waste reduction for resource-saving production.
6	**Assessments:** ☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)

zu	**Type of examination**	**Duration or scope**	**Weighting for the module grade**
a)	written or oral examination	90 - 120 minutes or 45 - 60 minutes	100%

7	**Study Achievement:** none
8	**Prerequisites for participation in examinations:** None
9	**Prerequisites for assigning credits:** The credit points are awarded after the module examination (MAP) was passed.
10	**Weighting for overall grade:** The module is weighted according to the number of credits (factor 1).
11	**Reuse in degree courses or degree course versions :** Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4
12	**Module coordinator:** Prof. Dr. Thomas Tröster
13	**Additional Notes:** None

NEU25 Introduction to Additive Manufacturing & Manufacturing Technology			
Introduction to Additive Manufacturing & Manufacturing Technology			
Module number: M.104.6173	**Workload (h):** 180	**Credits:** 6	**Regular Cycle:** winter term
Language: en	**Semester number:** 1.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** P

1 **Module structure:**

	Course	**form of teachin**	**contact-time (h)**	**self-study (h)**	**status (C/CE)**	**group size (TN)**
a)	L.104.32234 Introduction to Additive Manufacturing & Manufacturing Technology	L1 Ex1	75	105	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

none

4	**Contents:** 1. basics of additive manufacturing • Classification of different processes • Basic process chain for AM • Advantages and disadvantages of additive manufacturing 2. Overview of the most important additive manufacturing processes 2.1 Polymer materials • Extrusion process • Powder bed process • Lithography process 2.2 Metallic materials • Laser beam melting • Electron beam melting • Direct metal deposition 3. Classification of manufacturing processes 4. primary forming processes 5. separating manufacturing processes • Cutting with geometrically defined cutting edge • Machining with geometrically indeterminate cutting edge 6. Forming manufacturing processes • Fundamentals of forming technology • Solid forming processes • Sheet metal forming
5	**Learning outcomes and competences:** Students know the basics of additive manufacturing as well as the most important process principles and can explain them. They will be able to classify and discuss the advantages and disadvantages of the various additive manufacturing processes in comparison to conventional manufacturing processes. Students have basic knowledge of machining, forming and joining manufacturing processes and are able to classify the basic properties of manufacturing processes such as manufacturing accuracy and surface quality. They are familiar with the conceptual and theoretical foundations and interrelationships of manufacturing technology in order to understand overarching problems. On this basis, students will be able to select and explain suitable manufacturing processes for the requirements placed on a product to be manufactured, particularly against the background of sustainability.

<table>
<tr><td>6</td><td>Assessments:
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<tr><td>8</td><td>Prerequisites for participation in examinations:
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<tr><td>9</td><td>Prerequisites for assigning credits:
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<tr><td>10</td><td>Weighting for overall grade:
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<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr. Hans-Joachim Schmid, Prof. Dr.-Ing. Werner Homberg</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Materials Science of Plastics

Materials Science of Plastics

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.6174	150	5	summer term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	1.	1	P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.42245 Materials Science of Plastics	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

A deep understanding of the structural properties of macromolecules and polymers is crucial for the development of modern, high-performance plastic applications. The modification of plastics makes it possible to adapt their properties to modern requirements, particularly with regard to efficiency and performance. The thermal processes of melting and cooling influence the material structure and are analysed in terms of their significance for processing and application. The focus is on the mechanical and physical properties of solid plastics in order to gain a comprehensive understanding of their potential applications. Aspects of material damage, recycling and the circular economy are also addressed in order to promote the long-term sustainability and recyclability of plastics. Finally, the consideration of material selection provides an overview of the diverse areas of application and their specific requirements. This results in the following topics for this course:

- Structural properties of macromolecules and polymers
- Modification of plastics, taking into account modern requirements for efficiency and sustainability
- Melting and cooling of plastics
- Mechanical properties of solid plastics
- Various physical properties of solid plastics
- Material degradation, recycling and aspects of the circular economy
- Application areas and material selection

5 **Learning outcomes and competences:**

After attending the course, they will be able to assess the mechanical material behavior of plastics, taking into account the conditions of use, the material type and the material production, in order to be able to make a suitable material selection in design.

<table>
<tr><td>6</td><td>Assessments:
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<table>
<tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr>
<tr><td>a)</td><td>written or oral examination</td><td>90 - 120 minutes or 45 - 60 minutes</td><td>100%</td></tr>
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<tr><td>7</td><td>Study Achievement:
none</td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
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<tr><td>9</td><td>Prerequisites for assigning credits:
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<tr><td>10</td><td>Weighting for overall grade:
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<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1</td></tr>
<tr><td>12</td><td>Module coordinator:
Dr.-Ing. Florian Brüning, Prof. Dr.-Ing. Elmar Moritzer</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Powder Technology			
Powder Technology			
Module number: M.104.6175	**Workload (h):** 150	**Credits:** 5	**Regular Cycle:** winter term
Language: en	**Semester number:** 1.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.32217 Powder Technology	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

The Powder Technology course covers the basics of handling powder materials required for additive manufacturing. The fundamentals as well as applications and measurement methods that are necessary for efficient powder handling are presented. The lecture deals, for example, with the following topics

- Particle characterisation (size, shape, distribution)
- Measurement technology (image analysis, laser diffraction, sieve analysis, ring shear device, Hausner factor, etc.)
- adhesive forces
- Bulk solids mechanics (continuum properties vs. individual particles)
- Basics of filtration (separation, air purity)
- Conveying
- Powder production (metal and plastic)
- sieving

5 **Learning outcomes and competences:**

Students understand the measurement techniques in the powder area and can interpret the results reliably. They understand the interaction of individual particles and can predict bulk behaviour. They can identify relevant powder properties for additive manufacturing and characterise powders accordingly.

<table>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)<table><tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr><tr><td>a)</td><td>written or oral examination</td><td>120 - 150 minutes or 45 - 60 minutes</td><td>100%</td></tr></table></td></tr>
<tr><td>7</td><td>Study Achievement:
none</td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
None</td></tr>
<tr><td>9</td><td>Prerequisites for assigning credits:
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<tr><td>10</td><td>Weighting for overall grade:
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Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4</td></tr>
<tr><td>12</td><td>Module coordinator:
Dr.-Ing. Steffen Jesinghausen, Prof. Dr. Hans-Joachim Schmid</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Structure Optimization			
Structure Optimization			
Module number: M.104.6176	**Workload (h):** 150	**Credits:** 5	**Regular Cycle:** summer term
Language: en	**Semester number:** 2.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.11280 Structure Optimization	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

Structural optimization systematically explores how materials can be efficiently utilized and their performance enhanced. This scientific approach enables the creation of resource-efficient innovations and lays the foundation for technological progress. Within the lecture, the following topics will be covered:

- Basics of CAD Modeling
- Fundamentals of Optimization
- Optimization Methods
- Simulation-based Optimization
- Parameter Optimization and Design-of-Experiments
- Optimization Algorithms
- Application of Optimization in Practice
- Software Support for Structural Optimization
- Sustainable and efficient optimization algorithms

5 **Learning outcomes and competences:**

In the context of sustainable and resource-efficient development, structural optimizations are a prevalent method for realizing these ambitions. Therefore, students will be provided with the mathematical background and practical guidance for applying various optimization methods and algorithms, transforming theoretical knowledge into practical skills.
Upon completion of the course, students will be able to:

- Construct optimization models in CAD, focusing on geometry preparation
- Make informed decisions on the suitability of different optimization methods for various problems
- Analyze and discuss results based on the assumptions made
- Familiarize themselves with various commercial software tools to apply the theoretically conveyed concepts in practice.

6 **Assessments:**

☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)

zu	**Type of examination**	**Duration or scope**	**Weighting for the module grade**
a)	written or oral examination	90 - 120 minutes or 45 - 60 minutes	100%

7 **Study Achievement:**

none

8 **Prerequisites for participation in examinations:**

None

9 **Prerequisites for assigning credits:**

The credit points are awarded after the module examination (MAP) was passed.

10 **Weighting for overall grade:**

The module is weighted according to the number of credits (factor 1).

11 **Reuse in degree courses or degree course versions :**

Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4

12 **Module coordinator:**

Prof. Dr. Iryna Mozgova

13 **Additional Notes:**

None

NEU25 Design Rules for Additive Manufacturing

Design Rules for Additive Manufacturing

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.6177	150	5	summer term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	2.	1	P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.14242 Design Rules for Additive Manufacturing	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

The lecture describes the design freedoms and restrictions of additive manufacturing based on the individual process characteristics. Necessary methods for the systematical development of design rules for additive manufacturing are explained and deepened using application examples. The design guidelines relate to the following design aspects:

- production-orientated design
- design suitable for the support material
- design for post-processing
- design for accuracy The application of design rules for additive manufacturing significantly contributes to sustainability by reducing material consumption, saving energy, extending product life cycle, minimizing transport issues, and promoting the use of more environmentally friendly materials. These advantages not only benefit the environment but also support economic aspects by lowering production costs and increasing resource efficiency. The lecture focuses on the following additive manufacturing processes: Laser Powder Bed Fusion (LPBF), Selctive Laser Sintering (SLS) and Fused Deposition Modelling (FDM).

<table>
<tr><td>5</td><td>Learning outcomes and competences:
Students are familiar with the design advantages and disadvantages of additive manufacturing processes and can explain these using the design rules. They understand the procedure for developing design rules. Furthermore, they create the connection between the necessity of adhering to these rules for robust production and the consequences of non-compliance for production and application. By applying the rules, students are able to evaluate existing designs and, if necessary, optimize them or independently solve an existing design problem more efficiently, sustainably, and with a focus on longer lifetime. This competence enables students to safely develop components in all design phases and design them sustainably for additive manufacturing.</td></tr>
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<tr><td>12</td><td>Module coordinator:
Prof. Dr. Balázs Magyar</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Product Creation			
Product Creation			
Module number: M.104.6178	**Workload (h):** 150	**Credits:** 5	**Regular Cycle:** summer term
Language: en	**Semester number:** 2.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.51255 Product Creation	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

none

4	**Contents:** The market success of innovative and sustainable products is based on excellence in product creation. Product creation encompasses strategic product planning, innovation management, product engineering, production preparation and continuous information technology support, digital and virtual engineering. The product creation process thus ranges from strategic business field planning to market entry and is becoming increasingly important, especially in the context of the ongoing digital transformation and the need to develop sustainable products – in the sense of a circular economy. To increase effectiveness and efficiency in interdisciplinary product engineering, the value system, design principles, methods and tools are presented and applied on the basis of a product engineering system. This enables students to analyse product creation processes in different sectors with regard to potential for improvement and to develop concepts for reorganisation based on this. The module Product Creation provides an in-depth insight into the product creation process, that a conversion to a circular economy and sustainable product development entails. The first part focuses on the development of strategies and business models and the second section on development management. Contents of the course Product Creation: • Circular Economy and sustainable product engineering • Fundamentals of the Product Lifecycle • Product Life Cycle Management (PLM) • Digital and Virtual Product Creation • Development Methodology according to VDI 2206 and VDI 2221 • Strategic product planning • Requirements Engineering • System Architecture • Discipline-Specific Engineering • Design for Sustainability and R-Strategies • Prototyping (HiL, SiL, XiL) • Planning and Execution of Verification and Validation • Production Planning and Implementation • Resource Efficiency in Product Creation • Digital Twins in Product Use and Operation • Digital Twins in Service • End-of-Life Processes using the Example of Disassembly
5	**Learning outcomes and competences:** After completing the Product Creation course, students will be able to grasp the effects of the circular economy on product creation, to derive their effects on the product life cycle and business models, and to explain their prerequisites for resource-saving value creation. Depending on application criteria, they select suitable methods and procedures for product development and apply these to engineering problems. Overall, they will be able to apply selected methods and procedures of product development to new situations. Students are familiar with approaches to Requirements Engineering, design for X (e.g. Design for Recycling or Design for Ergonomics), Systems Engineering and complexity management and are able to apply these. Students work independently on tasks based on the engineering methods taught. They are familiar with current, resource-efficient approaches to effective and efficient production, such as digitalisation, and apply these. They also gain an overview of product life cycle management.

<table>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)
<table><tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr><tr><td>a)</td><td>written examination or homework assignment</td><td>90 - 120 minutes or 10 - 40 pages</td><td>100%</td></tr></table></td></tr>
<tr><td>7</td><td>Study Achievement:
none</td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
None</td></tr>
<tr><td>9</td><td>Prerequisites for assigning credits:
The credit points are awarded after the module examination (MAP) was passed.</td></tr>
<tr><td>10</td><td>Weighting for overall grade:
The module is weighted according to the number of credits (factor 1).</td></tr>
<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr. Iris Gräßler</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Standard Software Application Development			
Standard Software Application Development			
Module number: M.104.6179	**Workload (h):** 150	**Credits:** 5	**Regular Cycle:** winter term
Language: en	**Semester number:** 3.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.11275 Standard Software Application Development	L2 Ex2	60	90	C	40

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

The students are introduced to the Python programming language, through which the conveyed concepts and algorithms are applied in practice. This also includes the use of software libraries to solve industrial problems. The fundamentals of data organization, analysis, and storage, as well as IT security topics, contribute to competent handling in modern application scenarios. Python is understood as a modern programming language, among other things, as an interface between various systems. Modularization, scalability, and quality of software ensures resource-efficient (in terms of time, costs, and energy) and thus sustainable development. Numerous examples and practical exercises enhance understanding and immediate application.
Contents of the lecture:

- Introduction to programming with Python
- Software design and algorithmic fundamentals
- Application scenarios
- Data organization, analysis, and storage
- IT security

5 **Learning outcomes and competences:**

The course is aimed at students who want to learn more than the “normal” use of software, who want to deepen their knowledge of software design and its practical application during their studies. Examples and practical exercises promote understanding and direct application. Lectures and practical exercises are closely interlinked in the course in order to optimally adapt the course content to the students’ level of knowledge.

<table>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)<table><tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr><tr><td>a)</td><td>Written or oral examination</td><td>90 - 120 minutes or 45 - 60 minutes</td><td>100%</td></tr></table></td></tr>
<tr><td>7</td><td>Study Achievement:
none</td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
None</td></tr>
<tr><td>9</td><td>Prerequisites for assigning credits:
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<tr><td>10</td><td>Weighting for overall grade:
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<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr. Iryna Mozgova</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

3 Technical elective modules

<table>
<tr><th colspan="5">NEU25 3D-Printing of Ceramics</th></tr>
<tr><td colspan="5">3D-Printing of Ceramics</td></tr>
<tr><td>Module number:
M.104.8301</td><td>Workload (h):
150</td><td>Credits:
5</td><td colspan="2">Regular Cycle:
summer term</td></tr>
<tr><td>Language:
en</td><td>Semester number:
2.-4.</td><td>Duration (in sem.):
1</td><td colspan="2">Module status (P=C/WP=CE)
WP</td></tr>
<tr><td>1</td><td colspan="4">Module structure:
<table>
<tr><th></th><th>Course</th><th>form of teachin</th><th>contact-time (h)</th><th>self-study (h)</th><th>status (C/CE)</th><th>group size (TN)</th></tr>
<tr><td>a)</td><td>L.104.23250
3D-Printing of Ceramics</td><td>L2
Ex2</td><td>60</td><td>90</td><td>C</td><td>35</td></tr>
</table></td></tr>
<tr><td>2</td><td colspan="4">Options within the module:
None</td></tr>
<tr><td>3</td><td colspan="4">Admission requirements:
none</td></tr>
<tr><td>4</td><td colspan="4">Contents:
Introduction and application examples
Fundamentals of ceramic materials
3D printing of ceramics
Post-processing</td></tr>
<tr><td>5</td><td colspan="4">Learning outcomes and competences:
Students learn about 3D printing with ceramics and are able to use their knowledge of the construction process to geometrically design ceramic components for production. They will also be shown how ceramic materials must be prepared in advance of 3D printing and post process after the manufacturing process.</td></tr>
</table>

<table>
<tr><td>6</td><td>Assessments:
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<tr><td>7</td><td>Study Achievement:
none</td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
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<tr><td>9</td><td>Prerequisites for assigning credits:
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<tr><td>11</td><td>Reuse in degree courses or degree course versions :
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<tr><td>12</td><td>Module coordinator:
Prof. Dr. Mirko Schaper</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Additive Consulting

Additive Consulting

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.8302	150	5	summer term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	2.-4.	1	WP

1 **Module structure:**

	Course	**form of teachin**	**contact-time (h)**	**self-study (h)**	**status (C/CE)**	**group size (TN)**
a)	L.104.51240 Additive Consulting	L2 Ex2	60	90	C	35

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

Additive manufacturing is becoming increasingly relevant and is opening up new possibilities both in manufacturing and in the development of products. The task of tomorrow's engineers will therefore be to tap into the potential of additive manufacturing technologies, for example in the form of radical lightweight construction or component integration for company-specific product ranges. Additive manufacturing processes present companies with new challenges and require adaptations in both the development and manufacture of products. This course will provide you with the necessary tools for this:

- Basics of (additive) consulting
- Strategic planning of additively manufactured products
- Development of business models for additive manufacturing
- Consideration of circular economy in additive manufacturing (e.g. through the use of recycled materials)
- Customer requirements
- Technology selection
- Cost calculation
- Project management

5	**Learning outcomes and competences:** The Additive Consulting (AC) module teaches both basic and application skills for future engineers. The students explain basic principles and interrelationships of methods and tools used in additive consulting. They describe these using practical examples. They also explain processes for strategic planning in terms of the product life cycle. They will apply the acquired knowledge and procedures to new case studies. This enables them to analyze their applicability to different situations and to solve specific problems successfully and quickly. Students analyze existing manufacturing processes and procedures and supplement them with the new approach of additive manufacturing. In doing so, they take customer-specific requirements into account and create individual solutions. They list the factors to be considered for the introduction of additive manufacturing processes throughout the entire product life cycle.
6	**Assessments:** ☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)

zu	**Type of examination**	**Duration or scope**	**Weighting for the module grade**
a)	Written or oral examination	90 - 120 minutes or 45 - 60 minutes	100%

7	**Study Achievement:** none
8	**Prerequisites for participation in examinations:** None
9	**Prerequisites for assigning credits:** The credit points are awarded after the module examination (MAP) was passed.
10	**Weighting for overall grade:** The module is weighted according to the number of credits (factor 1).
11	**Reuse in degree courses or degree course versions :** Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4
12	**Module coordinator:** Prof. Dr. Iris Gräßler
13	**Additional Notes:** None

NEU25 Computer Aided Alloy Design			
Computer Aided Alloy Design			
Module number: M.104.8313	**Workload (h):** 150	**Credits:** 5	**Regular Cycle:** summer term
Language: en	**Semester number:** 2.-4.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** WP

1 **Module structure:**

	Course	**form of teachin**	**contact-time (h)**	**self-study (h)**	**status (C/CE)**	**group size (TN)**
a)	L.104.23255 Computer Aided Alloy Design	L2 Ex2	60	90	C	35

2 **Options within the module:**
None

3 **Admission requirements:**
none

4	**Contents:** The implementation of new materials has always been a very long process, experimentally intensive and high cost. This fact has generally removed new materials as an option to solve certain technological problems. However, computer-based material development enables the systematic design of materials through the use of thermodynamic simulations. The application of the CALPHAD method with As a basis for this development, the materials engineering approach utilizes the Calculated Phase Diagram (CALPHAD) method interfaced with thermo-chemical models to configure a science-based printable design. enables the combination of process-structure-performance. Material performance is also defined by practical performance requirements. In addition, case studies on interdisciplinary multiphysical cooperative modeling with applications in different material classes will be discussed. General materials design principles • Materials as a system • System engineering approach • Properties/performance correlation (1 lab); definition of property targets Fundamentals of the thermodynamics of materials • Enthalpy, entropy, Gibbs energy, • Equilibrium in single and multi-component systems • CALPHAD method Thermodynamic design models • Nucleation & coarsening • Solidification • Martensite • Grain coarsening • Precipitation hardening in steels • Brittle-ductility-temperature Design Software • Thermodynamic design of the microstructure • Computer-based thermodynamics software: ThermoCalc & ICMD • Dynamics Software: DICTRA & PRISMA Applications of computer-based material design in practice • Tool steels for additive manufacturing • Tesla: GigaCasting aluminum alloy • SpaceX: Mars Starship stainless steel outer skin • Apple: iWatch housing
5	**Learning outcomes and competences:** -

<table>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)<table><tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr><tr><td>a)</td><td>Written or oral examination</td><td>90 - 120 minutes or 45 - 60 minutes</td><td>100%</td></tr></table></td></tr>
<tr><td>7</td><td>Study Achievement:
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<tr><td>8</td><td>Prerequisites for participation in examinations:
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<tr><td>9</td><td>Prerequisites for assigning credits:
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<tr><td>10</td><td>Weighting for overall grade:
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<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4</td></tr>
<tr><td>12</td><td>Module coordinator:
Dr.-Ing. Florian Hengsbach, Prof. Dr. Mirko Schaper</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Design for Additive Manufacturing

Design for Additive Manufacturing

Module number:	Workload (h):	Credits:	Regular Cycle:
M.104.8315	150	5	winter term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	2.-4.	1	WP

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.14240 Design for Additive Manufacturing	L2 Ex2	60	90	C	35

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

In this lecture, methods for the design development of AM components are presented and explained. The lecture provides insights into useful software tools that support the development phase of AM components on a digital level. By focusing on additive manufacturing in product design and development, students can create more sustainable products that consume fewer resources, are more energy-efficient, and have a longer life cycle. This not only reduces environmental impact but also leads to cost savings and increased competitiveness. The effects of additive manufacturing on the following development phases are considered as follows:

- In the concept phase, functional improvements through the utilization of geometrical and material freedoms in additive manufacturing are assessed and compared with conventional manufacturing processes using specific key values.
- At the beginning of the design phase, the selection of the respective manufacturing process is analyzed, whereby hybrid process chains are also considered. The focus is on the consideration of design rules, geometrical deviations and suitable post-processing methods for additively manufactured components. The lecture content is applied in a central exercise and a practical course using example tasks. The design problems and task-specific aspects are explained together and solved in plenary sessions.

<table>
<tr><td>5</td><td>Learning outcomes and competences:
Students are familiar with the methods for the design development of AM components. Based on the knowledge they have acquired, they understand the sequence of the basic development phases and carry them out independently. They are able to solve existing functions with the help of AM-specific active principles and implement these in geometrical shapes. Students also have the expertise to independently develop designs in line with additive manufacturing and to critically check existing designs and create optimizations. They can select suitable software tools to support them during the development phases in order to develop resource-efficient components and assemblies.</td></tr>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)
<table>
<tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr>
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<tr><td>9</td><td>Prerequisites for assigning credits:
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<tr><td>12</td><td>Module coordinator:
Prof. Dr. Balázs Magyar</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Experimental Methods

Experimental Methods

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.8320	150	5	winter term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	2.-4.	1	WP

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.23265 Experimental Methods	L2 Ex2	60	90	C	35

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

The lecture provides an overview of the most important methods for characterizing materials and determining material properties. The focus of the course is on experimental methods that students can later use directly at the chair for their student research projects, Bachelor's or Master's theses. The theoretical part of the course is deepened by demonstrations on the equipment. The possibilities and limitations of the following experimental techniques will be presented and discussed in the course:

- light-optical methods,
- Scanning electron microscopy,
- EBSD,
- Transmission electron microscopy,
- X-ray diffractometry,
- Tensile testing,
- Digital image correlation.

5 **Learning outcomes and competences:**

The students know the most important methods for the characterization of materials and the determination of material properties. The focus of the course is on experimental methods which the students can later use in the field of materials (further) development.
The students are able to recognize the optimal method of investigation for specific materials science questions and they are able to interpret the results.

<table>
<tr><td>6</td><td>Assessments:
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Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr. Mirko Schaper</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Mechanics of Plastics

Mechanics of Plastics

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.8340	150	5	winter term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	2.-4.	1	WP

1 **Module structure:**

	Course	**form of teachin**	**contact-time (h)**	**self-study (h)**	**status (C/CE)**	**group size (TN)**
a)	L.104.42265 Mechanics of Plastics	L2 Ex2	60	90	C	35

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

The course covers the basic concepts and mechanical behaviour of plastics. Topics include linear elastic and elastoplastic material behaviour, mechanical equations of state for plastic deformation and rheological models to describe flow properties. In addition, material reduction through lighter plastic components and increased material efficiency through better understanding of plastics under mechanical load will be covered. The course offers valuable insights for the practical optimisation of plastics in engineering processes.

- Basic concepts of material mechanics
- Linear-elastic material behaviour
- Elastoplastic material behaviour
- Mechanical equation of state for the plastic part of the total deformation
- Specific description for oscillating loads
- Rheological models
- Material reduction
- Increased material efficiency

5 **Learning outcomes and competences:**

After attending the course, they will be able to assess the mechanical material behavior of plastics, taking into account the conditions of use, the material type and the material production, in order to be able to make a suitable material selection in design.

<table>
<tr><td>6</td><td>Assessments:
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<tr><td>10</td><td>Weighting for overall grade:
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<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr.-Ing. Elmar Moritzer</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Recycling of Plastics

Recycling of Plastics

Module number:	**Workload (h):**	**Credits:**	**Regular Cycle:**
M.104.8354	150	5	winter term
Language:	**Semester number:**	**Duration (in sem.):**	**Module status (P=C/WP=CE)**
en	1.-4.	1	WP

1 **Module structure:**

	Course	**form of teachin**	**contact-time (h)**	**self-study (h)**	**status (C/CE)**	**group size (TN)**
a)	L.104.42297 Recycling of Plastics	L2 Ex2	60	90	C	35

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

Implementing sustainable mechanical engineering involves switching from linear to circular management. However, this presents the entire economy with far more complex challenges than initially assumed. In this course, students will learn how the overall construct of politics, the economy, people and the environment are connected and which aspects must be taken into account for economic and sustainable recycling. To this end, the various recycling and utilisation methods for sustainable resource management are presented in full and an understanding of sustainable product design is sharpened. 1. Introduction 2. From linear to circular management 3. Processing the plastic fraction from waste 4. Material recycling 5. Recycling of raw materials 6. Thermal utilisation

5 **Learning outcomes and competences:**

Students will be able to understand and evaluate the recycling of plastics, taking into account technological, economic and political framework conditions. Furthermore, they will be able to recognise the differences between linear and circular management as well as obstacles in the transformation to an increased circular management. In addition, students learn how to design plastic products in such a way that effective recycling is possible and how to select suitable process technologies for the thermal, feedstock and material recycling of plastics.

<table>
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<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1</td></tr>
<tr><td>12</td><td>Module coordinator:
Dr.-Ing. Dennis Kleinschmidt, Prof. Dr.-Ing. Elmar Moritzer</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Tooling Technology – Planning, Manufacture, Postprocessing			
Tooling Technology – Planning, Manufacture, Postprocessing			
Module number: M.104.8221	**Workload (h):** 150	**Credits:** 5	**Regular Cycle:** summer term
Language: en	**Semester number:** 1.-4.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.24290 Tooling Technology – Planning, Manufacture, Postprocessing	L2 Ex2	60	90	C	35

2 **Options within the module:**

None

3 **Admission requirements:**

none

4 **Contents:**

- Introduction to machine tools
- Tool design and layout with CAD
- Method planning: FEM for tool design
- CAM in tool production
- Production measurement technology for measuring tools and workpieces

5 **Learning outcomes and competences:**

Students acquire basic skills in the design and interpretation of tools, especially with the use of CAD tools. They are also able to use methods from the field of FEM for the design of tools. With regard to the production of forming tools, knowledge in the area of CAM is acquired so that simple CNC milling programs can be created. In-depth skills are acquired in the area of measuring tools and workpieces. This enables students to design and design forming tools for the sustainable production of sheet metal components, to enable their production and to ensure their usability.

<table>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)<table><tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr><tr><td>a)</td><td>Written or oral examination</td><td>90 - 120 minutes or 45 - 60 minutes</td><td>100%</td></tr></table></td></tr>
<tr><td>7</td><td>Study Achievement:
none</td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
None</td></tr>
<tr><td>9</td><td>Prerequisites for assigning credits:
The credit points are awarded after the module examination (MAP) was passed.</td></tr>
<tr><td>10</td><td>Weighting for overall grade:
The module is weighted according to the number of credits (factor 1).</td></tr>
<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr.-Ing. Werner Homberg</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

NEU25 Visualization and Industry 4.0			
Visualization and Industry 4.0			
Module number: M.104.8367	**Workload (h):** 150	**Credits:** 5	**Regular Cycle:** summer term
Language: en	**Semester number:** 2.-4.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** WP

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	L.104.51285 Visualization and Industry 4.0	L2 Ex 2	60	90	C	35

2 **Options within the module:**
None

3 **Admission requirements:**
none

4	**Contents:** Product engineers use various methods to engineer products in a way that they satisfy requirements. A special requirement is eco-design: to achieve the highest possible degree of ecological sustainability “by design”. This applies not only for established design methodologies, but also for Generative Design and Design for Additive Manufacturing. Products shall be lightweight and utilize the freedom of design, but at the same time have to comply with testing requirements, shall enable both original part production as well as spare part logistics, and shall contribute to sustainable products in the future. The development of such kind of products and parts is increasingly conducted by model-based approaches. This requires interdisciplinary methods, but also tools for digital and virtual product creation are becoming indispensable. Their use often determines the effectiveness and efficiency of product engineering. An ecological footprint of a product can only be determined on the basis of comprehensive data management and the appropriate software tools. Digital tools facilitate the design and creation of AM products and corresponding manufacturing systems, virtual testing without manufacturing real prototypes and the collaboration of different actors across locations and companies. Based on these fundamentals, the module sets two focus points: Firstly, the importance of visualisation is transferred with regard to simulation and virtual prototyping, applying techniques of Virtual and Augmented Reality. Secondly, Additive Manufacturing is discussed as part of production and automation systems, spanning from digitalisation strategies to flexible, autonomously acting systems. Contents of the lecture: • Digital Engineering – Basics of Digital and Virtual Product Creation – Model Based Systems Engineering (MBSE) – Virtual und Rapid Prototyping – Generative Design and Design for Additive Manufacturing • Visualisation – Human-machine interaction, visualization and computer graphics – Fundamentals of Virtual and Augmented Reality (VR/AR) – Algorithms for real-time rendering – System architecture and hardware • Industry 4.0 and Manufacturing-X – Reference architecture for Industry 4.0 – Digital Factory – Application in terms of Industry 4.0 Contents of the exercise: • Human-machine interaction • Visualization und computer graphics • Tools of Digital and Virtual Product Creation – Model Based Systems Engineering (MBSE) – Simulation models – Production planning and control • Virtual and Augmented Reality (VR/AR) – Development Environment for Virtual and Augmented Reality – Optimization by algorithms for real-time rendering – Selection and use of system architecture and hardware

5	**Learning outcomes and competences:** The module “Visualization and Industry 4.0” provides both basic and application skills for future developers. Students know the essential basics and interrelationships of digital tools in the context of Digital and Virtual Engineering. They are able to explain them by applying them to examples, especially in the context of Additive Manufacturing. They apply the acquired knowledge and procedures with regard to selected software products and basic functions. This enables them to analyse their applicability to different situations and to solve specific problems successfully and quickly. Acquired competences in the application of process models and methods from the module “Product Creation” (M.104.7222) are extended by the use of digital tools and virtual reality. In the other seminars “Project lab Lean Production” (L.104.51480) and “Project lab Artificial Intelligence in Product Creation” (M.104.7706), specific problems in research and practice are solved with the help of digital tools.
6	**Assessments:** ☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)

zu	**Type of examination**	**Duration or scope**	**Weighting for the module grade**
a)	Written or oral examination	90 - 120 minutes or 45 - 60 minutes	100%

7	**Study Achievement:** none
8	**Prerequisites for participation in examinations:** None
9	**Prerequisites for assigning credits:** The credit points are awarded after the module examination (MAP) was passed.
10	**Weighting for overall grade:** The module is weighted according to the number of credits (factor 1).
11	**Reuse in degree courses or degree course versions :** Masterstudiengang Additive Manufacturing V1, Masterstudiengang Chemieingenieurwesen V3, Masterstudiengang Nachhaltiger Maschinenbau V1, Masterstudiengang Wirtschaftsingenieurwesen Studienrichtung Maschinenbau V4
12	**Module coordinator:** Dr.-Ing. Jens Pottebaum
13	**Additional Notes:** None

4 Industrial internship

<table>
<tr><th colspan="5">NEU25 Industriepraktikum / Industrial Internship</th></tr>
<tr><td colspan="5">Industrial Internship</td></tr>
<tr><td>Module number:
M.104.0072</td><td>Workload (h):
360</td><td>Credits:
12</td><td colspan="2">Regular Cycle:
summer- / winter term</td></tr>
<tr><td>Language:
de / en</td><td>Semester number:
2.</td><td>Duration (in sem.):
1</td><td colspan="2">Module status (P=C/WP=CE)
P</td></tr>
<tr><td>1</td><td colspan="4">Module structure:
<table>
<tr><th></th><th>Course</th><th>form of teachin</th><th>contact-time (h)</th><th>self-study (h)</th><th>status (C/CE)</th><th>group size (TN)</th></tr>
<tr><td>a)</td><td>Industrial Internship</td><td>P</td><td></td><td></td><td>C</td><td>1</td></tr>
</table></td></tr>
<tr><td>2</td><td colspan="4">Options within the module:
none</td></tr>
<tr><td>3</td><td colspan="4">Admission requirements:
none</td></tr>
<tr><td>4</td><td colspan="4">Contents:
Industrial project work in specialist areas in accordance with the internship regulations.</td></tr>
<tr><td>5</td><td colspan="4">Learning outcomes and competences:
The specialist internship is an engineering internship and serves to acquire practical experience with a predominant reference to mechanical engineering and/or process engineering. On the one hand, the specialist internship is intended to provide operational experience in the manufacture of products and the operation of mechanical engineering and/or process engineering systems and, on the other hand, experience in the fields of activity and fields of activity of engineers in mechanical engineering and/or process engineering. An important aspect of the internship is also the understanding of the social environment of the company. Students should understand the company in which they work as a social structure, in particular get to know the relationship between managers and employees and expand their social skills.</td></tr>
<tr><td>6</td><td colspan="4">Assessments:
Keine</td></tr>
</table>

<table>
<tr><td>7</td><td>Study Achievement:
<table>
<tr><th>zu</th><th>Type of achievement</th><th>Duration or Scope</th><th>SL / QT</th></tr>
<tr><td>a)</td><td>Internship report</td><td>2-3 pages per week</td><td>QP</td></tr>
</table></td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
none</td></tr>
<tr><td>9</td><td>Prerequisites for assigning credits:
The credit points are awarded after the qualified participation was achieved.</td></tr>
<tr><td>10</td><td>Weighting for overall grade:
No weighting for overall grade.</td></tr>
<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr. Hans-Joachim Schmid</td></tr>
<tr><td>13</td><td>Additional Notes:
Recognition of the internship report by the Internship Office of the Faculty of Mechanical Engineering and submission of an internship certificate issued by the company with detailed information on the scope and type of activities carried out.</td></tr>
</table>

5 Research paper

<table>
<tr><th colspan="5">NEU25 Studienarbeit / Research paper</th></tr>
<tr><td colspan="5">Research paper</td></tr>
<tr><td>Module number:
A.104.8019</td><td>Workload (h):
360</td><td>Credits:
12</td><td colspan="2">Regular Cycle:
summer- / winter term</td></tr>
<tr><td>Language:
en</td><td>Semester number:
3.</td><td>Duration (in sem.):
1</td><td colspan="2">Module status (P=C/WP=CE)
P</td></tr>
<tr><td>1</td><td colspan="4">Module structure:
<table>
<tr><th></th><th>Course</th><th>form of teachin</th><th>contact-time (h)</th><th>self-study (h)</th><th>status (C/CE)</th><th>group size (TN)</th></tr>
<tr><td>a)</td><td>Research paper</td><td></td><td>45</td><td>315</td><td>C</td><td>1</td></tr>
</table></td></tr>
<tr><td>2</td><td colspan="4">Options within the module:
None</td></tr>
<tr><td>3</td><td colspan="4">Admission requirements:
None</td></tr>
<tr><td>4</td><td colspan="4">Contents:
The content and assignment of the coursework will be determined by the examiner and given to the student in writing.</td></tr>
<tr><td>5</td><td colspan="4">Learning outcomes and competences:
The student is able to work independently on a limited but challenging problem using scientific methods within a fixed period of time and to select and apply suitable solution methods. Furthermore, the student is able to document the results in a clear and well-structured written form and to present and explain them in a comprehensible manner. Specific key competencies:
Independent project work under time pressure
Problem-solving skills
Project management
Dealing with scientific literature
Use of presentation tools, techniques and rhetoric
Writing a scientific paper</td></tr>
</table>

<table>
<tr><td>6</td><td>Assessments:
☒Final module exam (MAP) □Module exam (MP) □Partial module exams (MTP)<table><tr><th>zu</th><th>Type of examination</th><th>Duration or scope</th><th>Weighting for the module grade</th></tr><tr><td>a)</td><td>Written elaboration of the research paper and presentation</td><td>max. 80 pages / 30-45 min.</td><td>100%</td></tr></table></td></tr>
<tr><td>7</td><td>Study Achievement:
none</td></tr>
<tr><td>8</td><td>Prerequisites for participation in examinations:
None</td></tr>
<tr><td>9</td><td>Prerequisites for assigning credits:
The credit points are awarded after the module examination (MAP) was passed.</td></tr>
<tr><td>10</td><td>Weighting for overall grade:
The module is weighted according to the number of credits (factor 1).</td></tr>
<tr><td>11</td><td>Reuse in degree courses or degree course versions :
Masterstudiengang Additive Manufacturing V1</td></tr>
<tr><td>12</td><td>Module coordinator:
Prof. Dr. Hans-Joachim Schmid</td></tr>
<tr><td>13</td><td>Additional Notes:
None</td></tr>
</table>

6 Master‘s thesis

NEU25 Abschlussmodul Masterarbeit / Master‘s Thesis (Additive Manufacturing)			
Master‘s Thesis (Additive Manufacturing)			
Module number: A.104.7090	**Workload (h):** 750	**Credits:** 25	**Regular Cycle:** summer- / winter term
Language: en	**Semester number:** 4.	**Duration (in sem.):** 1	**Module status (P=C/WP=CE)** P

1 **Module structure:**

	Course	form of teachin	contact-time (h)	self-study (h)	status (C/CE)	group size (TN)
a)	Master‘s Thesis		75	585	C	1
b)	Oral Presentation		15	75	C	1

2 **Options within the module:**

None

3 **Admission requirements:**

Only those who have already earned at least 80 credit points at the time of application for admission, have successfully completed the study project and industrial internship modules, and, in the case of a requirement, have demonstrated that they have passed the specified examinations, can be admitted to the master’s thesis.

4 **Contents:**

The contents and the task of the Master’s thesis are determined by the examiner and handed out to the student in writing.

5 **Learning outcomes and competences:**

The Master’s thesis is the final part of the university degree program. The student is able to independently analyze a limited but complex scientific problem according to scientific methods and rules, select suitable solution procedures and methods and apply them appropriately within a fixed period of time. They are able to interpret and evaluate the solutions developed. The student is also able to independently acquire missing detailed knowledge using appropriate scientific literature. They are also able to adequately document the results achieved in written form and to present and explain them in a scientifically correct manner. Specific key competencies:

- Scientific work
- Independent project work under time pressure
- Dealing with scientific literature
- Problem-solving skills
- Project management
- Use of presentation tools, techniques and rhetoric
- Writing a scientific paper

6 **Assessments:**

□Final module exam (MAP) □Module exam (MP) ⊠Partial module exams (MTP)

zu	**Type of examination**	**Duration or scope**	**Weighting for the module grade**
a)	Master‘s Thesis	max. 150 pages	22/25
b)	Oral Presentation	30 - 45 minutes	3/25

7 **Study Achievement:**

none

8 **Prerequisites for participation in examinations:**

Only those who have already earned at least 80 credit points at the time of application for admission, have successfully completed the study project and industrial internship modules, and, in the case of a requirement, have demonstrated that they have passed the specified examinations, can be admitted to the master’s thesis.

9 **Prerequisites for assigning credits:**

The credit points are awarded after all modul examinations were passed.

10 **Weighting for overall grade:**

The module is weighted according to the number of credits (factor 1).

11 **Reuse in degree courses or degree course versions :**

Masterstudiengang Additive Manufacturing V1

12 **Module coordinator:**

Prof. Dr. Hans-Joachim Schmid

13 **Additional Notes:**

None

Erzeugt am 15. Januar 2026 um 14:28.