



## **6.10.103E Implementing Provisions for the Master's Degree Program in Intelligent Manufacturing at Clausthal University of Technology, Faculty of Mathematics/Computer Science and Mechanical of July 11, 2022**

The Faculty of Mathematics/Computer Science and Mechanical Engineering adopted the following Implementing Provisions pursuant to section 7(3) in conjunction with section 44(1) of the Lower Saxony Higher Education Act (*Niedersächsisches Hochschulgesetz*) on July 11, 2022. They were approved by the Presidential Board of Clausthal University of Technology on July 26, 2022 (Mitt.TUC 2022, p. 396).

### **Preamble**

The present Implementing Provisions shall apply only in connection with the General Examination Regulations of TU Clausthal as most recently amended and shall contain all supplementary rules and arrangements specific to the degree program.

### ***Ad*section 2**

#### **Objective of the program of study**

The master's degree program in intelligent manufacturing shall be a research-focused program aligned with the research profile of TU Clausthal and with the subject areas and fields of intervention of Industry 4.0. The overarching goal shall be to turn out students with highly-developed, interdisciplinary problem-solving faculties and core skills rooted in expertise in their disciplines to shape the future creation of products. The degree program shall be divided into two strands with a compulsory element and an elective element. In addition, the degree program shall comprise an interdisciplinary engineering project (IER), an interdisciplinary research project (IRP) and a master's thesis. The most important educational aims of the degree program shall be as follows:

- advanced knowledge of the core disciplines of manufacturing engineering, product development, data processing and analysis, open-loop and feedback control systems, and cyber-physical systems;
- knowledge and skills relating to physical/mathematical modeling and the simulation of selected manufacturing processes;
- expanded methodological competence for independently undertaking research and development tasks in the field of engineering with subject matter centered around Industry 4.0;
- specialization by means of selection of a particular direction and intensive induction into an area of practical application relevant to Industry 4.0;

- absorption of fundamental approaches and methods for scientific research and the production of academic papers (e.g. project work and publications);
- advancement of process and systems thinking and the skills required for structured problem solving and communication in interdisciplinary and international teams.

### ***Adsection 5*** **Program-specific Implementing Provisions**

The English-language master's program in intelligent manufacturing shall be modular in structure. The credit points allocated to each module under the European Credit Transfer System (ECTS) as well as the nature and scope of the required pieces of learning and assessment work shall be set out in Annex 1 (Module overview) to the present Provisions.

The following strands shall be available to choose from, each student being required to select exactly one of them:

- a. Manufacturing Analytics and Optimization
- b. Flexible and Intelligent Products and Processes

Annexes 2a to 2b shall each contain a model program schedule showing the recommended structure of the degree program.

A detailed description of the modules and in-depth information on the contents shall be made available in the separate module handbook.

### ***Adsection 6*** **Duration and structure of the degree program, credit points**

The degree program can be started in winter or summer semester. The model program schedule shall be based on a winter-semester start. If the program is begun in summer semester, it shall require an increased input of effort on the part of the student to adhere to the standard program duration.

The standard duration of the master's degree program in full-time study, including the master's thesis, shall be four semesters. The degree program shall comprise 120 credit points, of which 30 credit points shall be for the master's thesis including the colloquium.

### ***Adsection 10*** **Admission to examinations**

Before they register for their first piece of assessment work, it shall be recommended to all students of the master's degree program in intelligence manufacturing to discuss their choice of elective modules with the responsible program advisor. The outcome of this consultation shall be recorded in an individualized program schedule. The individualized program schedule thus drawn up shall not, however, be binding. Within the parameters of the options set out in Annex 1, students can deviate from the program schedule that has been drawn up.

A student's first attempt at an examination in any module belonging to one strand shall render their choice of strand binding. It shall be permissible to switch strands once, if no examination attempt within a module has yet been undertaken or is considered undertaken. A written application for the switch must be submitted to the Examinations Office in good time, before the newly chosen module from the other strand is taken.

A student's first attempt at an examination in an elective module shall render his or her choice of module binding. A change of elective modules shall only be possible if no examination attempt in an elective module has yet been undertaken or is considered undertaken.

### ***Ad*section 13**

#### **Structure of examinations, supplementary examinations, and examinations required to fulfill conditions**

The master's examination shall consist of the module and/or module-component examinations of the compulsory and elective modules as specified in Annex 1 and a master's thesis as specified in section 16 of the General Examination Regulations.

Catalogues of elective modules from Annex 1 can be updated once a year by Faculty Board decision. If changes are made to the catalogues of elective modules, they shall be published for each academic year via the Student Center by the end of the previous August, and any changes for the summer semester, which can be made in exceptional circumstances, shall be published by the end of the previous February here:

<https://www.tu-clausthal.de/studieninteressierte/studiengaenge/master-studiengaenge/intelligent-manufacturing>

Admission to module examinations, module-component examinations, and/or pieces of formative assessment can be made contingent on freely repeatable examination prerequisites. The examination prerequisites to be fulfilled shall be set out in Annex 1 (Module overview).

Pieces of formative assessment can be graded or ungraded. Whether a piece of formative assessment is graded or ungraded shall be set out in Annex 1 (Module overview).

All modules and the component courses and items of learning and assessment work shall be completed in English.

### ***Ad*section 14**

#### **Forms of learning and assessment work**

The form of required pieces of learning and assessment work shall be set out in Annex 1 (Module overview). If different forms of assessment can be required depending on examiners' choice, each examiner shall, in the first class of each course, detail and make known to the students the possible forms of assessment and, if applicable, permitted support tools specified in Annex 1. For written and oral examinations, (cf. section 15(3) and

(4) of the General Examination Regulations), the examination duration shall be laid down in the module handbook.

As part of the master's degree program in intelligent manufacturing, completion of an interdisciplinary engineering project (IEP) and an interdisciplinary research project (IRP) shall be required. The aim of these project assignments shall be to work at a practical level, in interdisciplinary teams, on example problems and questions proper to product creation and Industry 4.0, thereby not only advancing subject-specific expertise but also furthering problem-solving and methodological capabilities. Topics for the IEP and IRP shall be offered by two members of the TU Clausthal group of university teachers respectively. One of the members of the group of university teachers should represent the fields of product development and manufacturing while the other represents computer science and data analysis. The design of the questions and subject-related supervision shall be provided by both members of the group of university teachers and can be supplied by the following institutes:

- Institute of Electrical Power Engineering and Energy Systems
- Institute of Electrical Information Technology
- Institute of Computer Science
- Institute of Mechanical Engineering
- Institute of Welding and Machining
- Institute of Software and Systems Engineering
- Institute of Mathematics

Both modules – Interdisciplinary Engineering Project and Interdisciplinary Research Project – must be taken at an institute of TU Clausthal.

## ***Ad*section 16** **Final Thesis**

The master's thesis, including the colloquium, shall comprise 30 credit points and shall be completed within a timeframe of six months.

Upon application to the Examinations Committee and with the endorsement of the first assessor, that timeframe can be extended in exceptional circumstances to a total of nine months.

Separate admission in accordance with section 10 of the General Examination Regulations shall be required for the master's thesis. The first assessor shall be named in the application for that admission.

The examiner must be from the group of university teachers of TU Clausthal and attached to one of the following institutes:

- Institute of Electrical Power Engineering and Energy Systems
- Institute of Electrical Information Technology
- Institute of Computer Science
- Institute of Mechanical Engineering
- Institute of Welding and Machining
- Institute of Software and Systems Engineering

- Institute of Mathematics

Justified exceptions can be made upon application to the Examinations Committee.

Admission to the master's thesis shall be granted to applicants who, in addition to the prerequisites specified in section 10 of the General Examination Regulations, have accumulated at least 75 credit points. Justified exceptions can be made upon application to the Examinations Committee.

The grade for the master's thesis as a module examination shall be comprised of 90% for the written element and 10% for the oral element (colloquium).

### ***Ad*section 18**

#### **Evaluation of assessment work, calculation of grades**

The weighting ascribed to each module when calculating the overall grade for the master's examination shall be set out in Annex 1 (Module overview).

### ***Ad*section 22**

#### **Non-completion, cheating, exceptions**

This master's degree program in intelligent manufacturing shall not be suitable for part-time study.

### ***Ad*section 33**

#### **Entry into force**

The present Implementing Provisions shall enter into force on the day following their publication in the official journal of Clausthal University of Technology, the *Amtliches Verkündungsblatt*, for the beginning of the 2022/2023 winter semester examination period.

Annex 1: Module overview

Annex 2a: Model program schedule for the Manufacturing Analytics and Optimization strand

Annex 2b: Model program schedule for the Flexible and Intelligent Products and Processes strand

## Annex 1: Module overview for M.Sc. in Intelligent Manufacturing

<b>General compulsory modules for all strands</b>							
All the modules listed below, totaling 96 credit points, must be completed.							
<i>Module or course title</i>	<i>Course number</i>	<i>Course type hrs/week<sup>1)</sup></i>	<i>Credit points</i>	<i>Exam form<sup>2)</sup></i>	<i>Weight -ing</i>	<i>Graded ?</i>	<i>Asses. type<sup>3)</sup></i>
<b>Module: Big Data Management and Analytics</b>		4	6		6/Σ		
Big Data Management and Analytics	S 1246	3L + 1T	6	W/O	1	yes	ME
Home Assignment for Big Data Management and Analytics		0	0	HA	0	no	EP
<b>Module: Computer Integrated Manufacturing including Lab</b>		4	6		6/Σ		
Computer Integrated Manufacturing	S 8181	3L + 1T	4	W/O	4/5	yes	MCE
Lab: Computer Integrated Manufacturing	S 8160	1 lab	2	PA	1/5	yes	MCE
<b>Module: Advanced Cyber-Physical Systems</b>		4	6		6/Σ		
Advanced Cyber-Physical Systems	W 1260	3L + 1T	6	W/O	1	yes	ME
Home Assignment for Advanced Cyber-Physical Systems		0		HA	0	no	EP
<b>Module: Product Design and Process Planning for Casting</b>		4	6		6/Σ		
Product Design and Process Planning for Casting	W 7995	3V + 1Ü	6	W/O	1	yes	ME
<b>Module: Subtractive Manufacturing</b>		4	6		6/Σ		
Subtractive Manufacturing	W 8136	3L + 1T	6	W/O	1	yes	ME
<b>Module: System Automation</b>		4	6		6/Σ		
System Automation	W 8743	3L + 1T	6	W/O	1	yes	ME
<b>Module: Welding Manufacturing</b>		4	6		6/Σ		
Welding Manufacturing	S 8137	3L + 1T	6	W/O	1	yes	ME
<b>Module: Wireless Sensor Networks</b>		4	6		6/Σ		
Wireless Sensor Networks	W 1256	3L + 1T	6	W/O	1	yes	ME
Home Assignment for Wireless Sensor Networks		0		HA	0	no	EP
<b>Module: Interdisciplinary Engineering Project &amp; Seminar: Intelligent Manufacturing</b>		4	6		6/Σ		
Interdisciplinary Engineering Project (IEP)	W 8180	3lab	5	PA	4/5	yes	MCE
Seminar: Intelligent Manufacturing	W 8179	1S	1	SC	1/5	yes	MCE
<b>Module: Interdisciplinary Research Project</b>		4	6		6/Σ		
Interdisciplinary Research Methodology	S 8182	1L	1	O	1/5	yes	MCE
Interdisciplinary Research Project (IRP)	S 8180	3lab	5	PA	4/5	yes	MCE
<b>Module: Interdisciplinary and Cross-Culture Collaboration</b>		6	6		0		

<ul style="list-style-type: none"> <li>• In the module Interdisciplinary and Cross-Culture Collaboration, two courses or three courses/examinations amounting to exactly 6 credit points in total must be selected from the electives catalogue and successfully completed. Additional courses/examinations from this electives catalogue can only be undertaken as supplementary examinations.</li> <li>• A student's first examination attempt in a course/examination shall render their choice binding.</li> </ul>							
Elective course I	see catalogue	see catalogue	see catalogue	see catalogue	see catalogue	yes	FA
Elective course II	see catalogue	see catalogue	see catalogue	see catalogue	see catalogue	yes	FA
Elective course III	see catalogue	see catalogue	see catalogue	see catalogue	see catalogue	yes	FA
<b>Module: Master's Thesis</b>		<b>20</b>	<b>30</b>		<b>30/Σ</b>		
Master's Thesis incl. Colloquium		6 months	30	FT	1	yes	ME

### **Strands:**

#### **Selecting a strand**

- Each student must choose exactly one strand.
- Their first attempt at an examination in any module belonging to one strand shall render their choice of strand binding. A change of strands shall only be permissible if no examination attempt within a module has yet been undertaken or is considered undertaken. It shall be permissible to switch once, and a written application for the switch must be submitted to the Examinations Office in good time, before the newly chosen module from the other strand is taken.

#### **Strand: Flexible and Intelligent Products and Processes**

##### **Choice of Electives for Flexible and Intelligent Products and Processes**

- Modules amounting to exactly 24 credit points must be selected from the electives catalogue for Flexible and Intelligent Products and Processes and successfully completed. Additional examinations can only be undertaken as supplementary examinations.
- A student's first attempt at an examination in an elective module shall render their choice of module binding. A change of elective modules shall only be possible if no examination attempt in an elective module has yet been undertaken or is considered undertaken.

#### **Strand: Manufacturing Analytics and Optimization**

##### **Choice of Electives for Manufacturing Analytics and Optimization**

- Modules amounting to exactly 24 credit points must be selected from the electives catalogue for Manufacturing Analytics and Optimization and successfully completed. Additional examinations can only be undertaken as supplementary examinations.
- A student's first attempt at an examination in an elective module shall render their choice of module binding. A change of elective modules shall only be possible if no examination attempt in an elective module has yet been undertaken or is considered undertaken.

## Electives catalogues:

### Electives catalogue for the Flexible and Intelligent Products and Processes strand

The list of modules offered can be updated annually for the subsequent academic year by Faculty Board decision. The updated lists shall be published throughout the university by the Student Center:

**<https://www.tu-clausthal.de/studieninteressierte/studiengaenge/master-studiengaenge/intelligent-manufacturing>**

<i>Module or course title</i>	<i>Course number</i>	<i>Course type hrs/week</i>	<i>Credit points</i>	<i>Exam form</i>	<i>Weighting</i>	<i>Graded ?</i>	<i>Asses. type</i>
<b>Module: Additive Manufacturing using Polymers</b>		<b>4</b>	<b>6</b>		<b>6/Σ</b>		
Additive Manufacturing using Polymers	S 7985	4S/lab	6	W/O	1	yes	ME
<b>Module: Applied Computational Engines</b>		<b>4</b>	<b>6</b>		<b>6/Σ</b>		
Applied Computational Engines	W 1634	3L + 1T	6	W/O	1	yes	ME
Home assignment for Applied Computational Engines		0	0	HA	0	no	EP
<b>Module: Design for Industry 4.0</b>		<b>4</b>	<b>6</b>		<b>6/Σ</b>		
Design for Industry 4.0	S 8183	2L	3	W/O	2/5	yes	MCE
Lab: Design for Industry 4.0	S 8161	2lab	3	PA	3/5	yes	MCE
<b>Module: Laser Sensors</b>		<b>4</b>	<b>6</b>		<b>6/Σ</b>		
Laser Sensors	W 8935	4L/T	6	W/O	1	yes	ME
<b>Module: System Identification +</b>		<b>4</b>	<b>6</b>		<b>6/Σ</b>		
System Identification +	S 8932	3L + 1T	6	W/O	1	yes	ME



## Electives catalogue for the Manufacturing Analytics and Optimization strand

The list of modules offered can be updated annually for the subsequent academic year by Faculty Board decision. The updated lists shall be published throughout the university by the Student Center:

**<https://www.tu-clausthal.de/studieninteressierte/studiengaenge/master-studiengaenge/intelligent-manufacturing>**

<i>Module or course title</i>	<i>Course number</i>	<i>Course type hrs/week</i>	<i>Credit points</i>	<i>Exam form</i>	<i>Weighting</i>	<i>Graded ?</i>	<i>Asses. type</i>
<b>Data Analysis and Statistical Learning modules</b>		4	6		6/Σ		
Data Analysis and Statistical Learning	S 0425	3L + 1T	6	W/O	1	yes	ME
Data Analysis and Statistical Learning home assignment		0	0	HA	0	no	EP
<b>Multi-Scale Simulation modules</b>		4	6		6/Σ		
Multi-Scale Simulation	W 8005	3L + 1T	6	W/O	1	yes	ME
<b>Product Data Management in Industry 4.0 modules</b>		4	6		6/Σ		
Product Data Management in Industry 4.0	S 8184	1L	1	W/O	1/5	yes	MCE
Product Data Management in Industry 4.0 lab	S 8188	3lab	5	PA	4/5	yes	MCE
<b>Simulation Engineering modules</b>		4	6		6/Σ		
Simulation Engineering	W 1269	3L + 1T	6	W/O	6	yes	ME
Simulation Engineering home assignment		0	0	HA	0	no	EP

## Electives catalogue for Interdisciplinary and Cross-Culture Collaboration

The list of modules offered can be updated annually for the subsequent academic year by Faculty Board decision. The updated lists shall be published throughout the university by the Student Center:

**<https://www.tu-clausthal.de/studieninteressierte/studiengaenge/master-studiengaenge/intelligent-manufacturing>**

<i>Module or course title</i>	<i>Course number</i>	<i>Course type hrs/week</i>	<i>Credit points</i>	<i>Exam form</i>	<i>Weighting</i>	<i>Graded ?</i>	<i>Asses. type</i>
Business English I	W/S 9096	2T	2	W/O	1/3	yes	FA
Chinese for Beginners	W 9200	4L	4	W/O	2/3	yes	FA
Intercultural Competence	W/S 9221	2T	2	W/O	1/3	yes	FA
Technical Writing	W/S 9009	2T	2	ThA	1/3	yes	FA
Technical Presentations in English	W/S 9092	2T	2	W/O	1/3	yes	FA
Technical English	W/S 9000	4L	4	W/O	2/3	yes	FA

## Key:

1) Types of course	L	=	lecture
	T	=	tutorial
	lab	=	laboratory class
	S	=	seminar
	E	=	excursion
2) Forms of examination	W	=	written examination
	O	=	oral exam
	SC	=	seminar contribution
	PrA	=	practical assignment
	ThA	=	theory assignment
	RA	=	research assignment
	PA	=	project assignment
	IP	=	industrial placement
	HA	=	home assignments
	Ex	=	excursions
FT	=	final thesis	
3) Types of assessment	ME	=	module examination
	MCE	=	module-component examination
	FA	=	formative assessment
	EP	=	examination prerequisites
4) Other abbreviations	exam	=	examination
	ECTS	=	European Credit Transfer System
	hrs/wk	=	class hours per week

Annex 2a: Model program schedule for the Flexible and Intelligent Products and Processes strand\_AFB 11.07.2022

hrs/wk	1st semester winter semester	2nd semester summer semester	3rd semester winter semester	4th semester summer semester
1	Subtractive Manufacturing 2L + 2T 6 credit points	Welding Manufacturing 2L + 2T 6 credit points	Product Design and Process Planning for Casting 2L + 2T 6 credit points	Master's Thesis incl. Colloquium 30 credit points
2				
3				
4				
5	System Automation 3L + 1T 6 credit points	Computer Integrated Manufacturing incl. Lab 2L + 1T + 1lab 6 credit points	Interdisciplinary Research Project 1L + 3lab 6 credit points	
6				
7				
8				
9	Wireless Sensor Networks 3L + 1T 6 credit points	Big Data Management and Analytics 3L + 1T 6 credit points	Advanced Cyber Physical Systems 3L + 1T 6 credit points	
10				
11				
12				
13	Interdisciplinary and Cross-Culture Collaboration 6 credit points	12 credit points (2 modules) from electives catalogue for Flexible and Intelligent Products and Processes strand	12 credit points (2 modules) from electives catalogue for Flexible and Intelligent Products and Processes strand	
14				
15				
16				
17				
18				
19				
20	Interdisciplinary Engineering Projects & Intelligent Manufacturing Seminar 1S + 3lab 6 credit points			
21				
22				
Total hrs/wk	22	20	20	20
Total credit points	30	30	30	30

**Strand: Flexible and Intelligent Products and Processes**

	Credit points
<b>Discipline-specific expertise and methodology</b>	<b>Σ 104</b>
Foundations of manufacturing engineering	30
Foundations of information technology	18
Interdisciplinary and methodological foundations	8
Focuses in engineering (strand)	24
Methodology of research and work (master's thesis)	24
<b>Personal competence and social skills</b>	<b>Σ 16</b>
Team and project work	4
Knowledge of language and culture	6
Applied working methods (master's thesis)	6

Annex 2b: Model program schedule for the Manufacturing Analytics and Optimization strand\_AFB 11.07.2022

hrs/wk	1st semester winter semester	2nd semester summer semester	3rd semester winter semester	4th semester summer semester
1	Subtractive Manufacturing 2L + 2T 6 credit points	Welding Manufacturing 2L + 2T 6 credit points	Product Design and Process Planning for Casting 2L + 2T 6 credit points	Master's Thesis 30 credit points
2				
3				
4				
5	System Automation 3L + 1T 6 credit points	Computer Integrated Manufacturing incl. Lab 2L + 1T + 1lab 6 credit points	Interdisciplinary Research Project 1L + 3lab 6 credit points	
6				
7				
8				
9	Wireless Sensor Networks 3L + 1T 6 credit points	Big Data Management and Analytics 3L + 1T 6 credit points	Advanced Cyber Physical Systems 3L + 1T 6 credit points	
10				
11				
12				
13	Interdisciplinary and Cross-Culture Collaboration 6 credit points	12 credit points (2 modules) from the electives catalogue for the Manufacturing Analytics and Optimization strand	12 credit points (2 modules) from the electives catalogue for the Manufacturing Analytics and Optimization strand	
14				
15				
16				
17				
18				
19	Interdisciplinary Engineering Projects & Intelligent Manufacturing Seminar 1S + 3lab 6 credit points			
20				
21				
22				
Total hrs/wk	21	20	20	20
Total credit points	30	30	30	30

**Strand: Manufacturing Analytics and Optimization**

Credit points

<b>Discipline-specific expertise and methodology</b>	<b>Σ 104</b>
Foundations of manufacturing engineering	30
Foundations of information technology	18
Interdisciplinary and methodological foundations	8
Focuses in engineering (strand)	24
Methodology of research and work (master's thesis)	24
<b>Personal competence and social skills</b>	<b>Σ 16</b>
Team and project work	4
Knowledge of language and culture	6
Applied working methods (master's thesis)	6