Technische Hochschule Rosenheim

Faculty of Engineering

Curriculum

of the

Master's Program

Engineering Sciences
at Rosenheim Technical University of Applied Sciences

Status: March 7, 2023

Version ad99cf29 for students according to the SPO of 20231

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2 Overview of Available Courses

2.1 Courses offered by the Faculty of Engineering Sciences

This section gives an overview of available courses offered by the faculty of engineering sciences of the Technical University of Applied Sciences Rosenheim.

- A minimum of 10 CPs must be earned from the MG group of courses.
- A minimum of 10 CPs must be earned from the MA group of courses.
- A minimum of 20 CPs must be earned from the MV group of courses.
- A minimum of 13 CPs must be earned from the MF group of elective courses

2.1.1 MG group courses

No.	Module	SWS	ECTS	Form of Course	Examination 1)		Supplementary regulations
					Type and Duration	ZV	
MG01	Advanced Mathematics *Angewandte Mathematik*	4	5	SU, Ü	schrP 60-180 min, mdlP 20-60 min, elP 20-180 min or PStA 2-15 Wo	-	
MG02	Electrodynamics *Elektrodynamik*	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, elP 20-180 min or PStA 2-15 Wo	-	
MG03	Solid State Electronics *Festkörperelektronik*	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, elP 20-180 min or PStA 2-15 Wo	-	
MG04	Statistics *Statistik*	4	5	SU, Ü	schrP 60-180 min, mdlP 20-60 min, elP 20-180 min or PStA 2-15 Wo	-	
MG05	Fluid Mechanics *Strömungsmechanik*	4	5	SU, Ü	schrP 60-180 min, mdlP 20-60 min, elP 20-180 min or PStA 2-15 Wo	-	
MG06	Applied numerical methods for mechanical engineering	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, elP 20-180 min or PStA 2-15 Wo	-	

Figure 1: MG group courses

1) At least a grade of 4.0 for all examination parts is necessary to pass the examination.

2.1.2 MA group courses

No.	Module	SWS	ECTS	Form of Course	Examination 1)		Supplementary regulations
					Type and Duration	ZV	
MA01	Real-Time Systems *Realzeitsysteme*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MA02	Integrated Circuit System Design and Test *IC-Systementwurf und -test*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MA03	Mixed Signal Systems *Mixed-Signal-Systeme*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MA04	Selected Topics in Assembly Technology *Ausgewählte Themen der Montagetechnik*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	2)	
MA05	Model based Development *Modellbasierter Entwurf*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	2)	
MA06	Materials from Renewable Resources *Materialien aus erneuerbaren Quellen*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	3)	

Figure 2: MA group courses

1) At least a grade of 4.0 for all examination parts is necessary to pass the examination.
2) Admittance to the examination is only possible, if you pass the lab course (LNmE).
3) Attendence of the seminar is necessary to get a grade for the module.

2.1.3 MV group courses

No.	Module	SWS	ECTS	Form of Course	Examination 1)		Supplementary regulations	EIT	MEC	MEN PEN
					Type and Duration	ZV				
MV01	Advanced Control Systems *Regelungstechnik*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X	X	
MV02	Industrial Process Control *Industrielle Steuerungstechnik*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X	X	
MV03	Servo Drive Systems *Servoantriebssysteme*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X	X	
MV04	Automation Systems *Automatisierungssysteme*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	2)		X	X	
MV05	Reliability of Mechatronic Systems *Zuverlässigkeit mechatronischer Systeme*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-			X	X
MV06	Wireless Communication Systems *Drahtlose Kommunikationsssysteme*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X		
MV07	Advanced Digital Communication *Nachrichtenübertragung*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X		
MV08	Digital Signal Processing and Machine Learning *Digitale Signal-verarbeitung und maschinelles Lernen*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X	X	
MV09	Advanced FEM *FEM*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-			X	X
MV10	Electromagnetic Compatibility *Elektromagnetische Verträglichkeit*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X	X	
MV11	Image Processing for Automated Production *Bildverarbeitung in der Produktion*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-		X	X	
MV12	Mechanical Design *Mechanische Konstruktion*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-			X	X
MV13	Advanced Lightweight Construction *Leichtbau Vertiefung*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-				X
MV14	Advanced Injection Molding *Spritzgusstechnologie*	4	5	SU, Ü	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-				X
MV15	Selected Topics of Polymer Chemistry and Materials Sciences *Ausgewählte Themen der Polymer-chemie und Materialwissenschaften*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-				X
MV16	Free Form Surfaces *Freiformflächen*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-				X
MV17	Mechanical Transmission *Getriebe Technologien*	4	5	SU, Pr	schrP 60-180 min, mdIP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-				X

Figure 3: MV group courses

1) At least a grade of 4.0 for all examination parts is necessary to pass the examination.
2) Admittance to the examination is only possible, if you pass the lab course (LNmE).

2.1.4 MF group courses

No.	Module	SWS	ECTS	Form of Course	Examination 1) Type and Duration	Examination 1) ZV	Supplementary regulations
MF01	Microelectronics	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF04	Applied Didactics	4	5	Tutorial	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF10	Electronics Packaging and Manufacturing	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF12	Satellite Navigation	4	5	SU	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF14	Power Electronics Circuit Design	2	3	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF20	RF and Microwave Systems	4	5	SU, Ü	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF22	Kalman Filtering in Control Systems and Communication	4	5	SU, Ü	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF23	Design of Materials	3	5	SU, Ü	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF24	Ceramics and other Sintering materials	2	3	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF30	Experimental Modelling and Simulation	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF31	Advanced Design for Additive Manufacturing / Int. Summer School (full ING part)	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF32	Intellectual Property Protection	2	3	SU	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF33	Heat Transfer	2	3	SU	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF36	Trajectory Planning for Robots and Automatic Machines	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF37	Chemistry of renewable resources	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	2)	
MF38	Chemical H2 conversion: Applications and industrial processes	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF39	International Summer School (1 week part - non ING)	2	2	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF42	Homogeneous Catalysis	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	
MF43	Techno-economic Analysis and Simulation	4	5	SU, Pr	schrP 60-180 min, mdlP 20-60 min, eIP 20-180 min or PStA 2-15 Wo	-	

Figure 4: MF group courses

1) At least a grade of 4.0 for all examination parts is necessary to pass the examination.
2) Admittance to the examination is only possible, if you pass the lab course (LNmE).

Please note that Technical University of Applied Sciences is under no obligation to offer an ENG Master's program elective course (MF group) when enrollment is insufficient!

A minimum number of 10 participants is required for elective courses (MF group) to take place. The Faculty Council of the Faculty of Engineering decides on cancellation of modules due to insufficient number of participants.

For courses which are mainly based on lab class work, enrollment may be limited.

On request courses from the MV group can be taken to fulfill the MF credits requirement of 13 CPs. However this has to be explicitly approved by the ENG-Master's Program Examination Commission.

Course MV06 comprises a lecture part MV06.1 and a lab class part MV06.2 which can only be taken in combination. The lab class part is graded separately and counts for the overall final mark.

2.1.5 Summer term 2023

No.	Modul / Course Title	EIT	MEC	MK	Lecturer	Type	Hours	CPs
MG01	Advanced Engineering Mathematics				Prof. Dr. Schulze	Lect./Exerc.	4	5
MG05	Fluid Mechanics				Prof. Dr. Buttinger / Prof. Dr. Schäfle	Lect./Exerc.	4	5
MA01	Real-Time Systems				Prof. Dr. Mysliwetz	Lect./Lab	4	5
MA03	Mixed Signal Systems				Prof. Dr. Stubenrauch	Lect./Lab	4	5
MA05	Model based development				Prof. Dr. Perschl	Lect./Lab	4	5
MA06	Materials from Renewable Resources				Prof. Dr. Schroeter	Lect./Exerc.	4	5
		EIT	MEC	MK				
MV07	Advanced Digital Communications	x			Prof. Dr. Stichler	Lect./Lab	4	5
MV10	Electromagnetic Compatibility	x	x		Prof. Dr. Seliger	Lect./Lab	4	5
MV12***	Mechanical Design		x	x	Prof. Dr. Ragai	Lect./Proj.	4	5
MV13	Advanced light weight construction			x	Prof. Dr. Riß	Lect./Exerc.	4	5
MV14	Advanced Injection Molding			x	Prof. Dr. Würtele	Lect./Proj.	4	5
MV17	Mechanical Transmission			x	Prof. Dr. Doleschel	Lect./Proj.	4	5
MF01	Microelectronics				Prof. Dr. Popp	Lect./Lab	4	5
MF04	Applied Didactics				offered on demand	Tutorial	2	3
MF14	Power Electronics Circuit Design				Prof. Dr. Seliger	Lect./Lab	2	3
MF24	Ceramics and other Sintering materials				Prof. Dr. Müller	Lect./Lab	2	3
MF30	Experimental Modelling and Simulation				Prof. Dr. Zentgraf	Lect./Lab	4	5
MF32	Intellectual Property Protection				LB Wagner	Lect.	2	3
MF33	Heat Transfer				Prof. Dr. Stanzel	Lect.	2	3
MF36	Trajectory Planning for Robots and Automatic Machines				Prof. Dr. King	Lect./Lab	4	5
MF37	Chemistry of renewable resources				Prof. Dr. List / Prof. Dr. Pentlehner	Lect./Lab	4	5
MF39***	International Master Summer School				Fac. WI / Fac. HT / Prof. Dr. Riß	Lect./Lab	4	2 / 5
MF43	Techno-economic Analysis and Simulation				Prof. Dr. Völkl	Lect./Lab	4	5
*	AW.0543.M Technical and Business English				Fr. Pötzinger	Lect.	4	5
*	ANG516 Business English				n.n.	Lect.	4	5
**	AW-0 05740.M Deutsch B1.1 / German B1.1				Fr. Edelmann	Lect.	4	5
**	AW-0 05750.M Deutsch B1.2 / German B1.2				Fr. Lembcke	Lect.	4	5
**	AW-0 05760.M Deutsch B2 kompakt / German B2				Fr. Mayr	Lect.	4	5
**	AW-0 05710.M DaF: Kommunizieren und Präsentieren / DaF: Communication and Presenta				Hr. Langsenlehner	Lect.	2	3
MP02	Master's Project						10	12
VHB	Scientific writing				Prof. Dr. Radon, LMU München		2	3
VHB	Medical Image Processing for Diagnostic Applications				Prof. Dr. Maier, Uni Erlangen-Nürnberg		4	5
VHB	Integrated Production Systems				Prof. Dr. Franke, Uni Erlangen-Nürnberg		4	5
VHB	Leadership and Communication in Global Business				Prof. Dr. Winkler, FH Kempten		2	3
VHB	Machine Learning for Engineers I				Prof. Dr. Eskofier, Uni Erlangen-Nürnberg		4	5

* for German students only: will be accepted as MF module (SPO2019 and SPO2016) restricted to a maximum of 5 Credit Points
** for non-German students only: will be accepted as MF module (SPO2019 and SPO2016) restricted to a maximum of 5 Credit Points
*** block course

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Figure 5: Engineering Sciences Master's Program – Courses offered in summer term 2023 (SPO2019)

2.1.6 Winter term 2023/24 (Preliminary)

No.	Modul / Course Title	EIT	MEC	MK	Lecturer	Type	Hours	CPs
MG02	Electrodynamics				Prof. Dr. Seliger	Lect./Exerc.	4	5
MG03	Solid State Electronics				Prof. Dr. Popp / Prof. Dr. Müller	Lect./Lab	4	5
MG04	Statistics				Prof. Dr. Schmiedt	Lect./Exerc.	4	5
MA02	Integrated Circuit Design and Test				Prof. Dr. Thurner / Prof. Dr. Versen	Lect./Exerc.	4	5
MA04	Selected topics in assembly technology				Prof. Dr. Meierlohr	Lect./Exerc.	4	5
MA06	Materials from Renewable Resources				Prof. Dr. Schroeter	Lect./Exerc.	4	5
		EIT	MEC	MK				
MV01	Advanced Control Systems	x	x		Prof. Dr. King	Lect./Lab	4	5
MV02	Industrial Process Control	x	x		**Prof. Dr. Krämer / Prof. Dr. Perschl**	Lect./Lab	4	5
MV03	Servo Drive Systems	x	x		Prof. Dr. Hagl	Lect./Lab	4	5
MV04	Automation Systems	x	x		Prof. Dr. Meierlohr	Lect./Lab	4	5
MV05	Reliability of Mechatronic Systems		x	x	Prof. Dr. Versen	Lect./Lab	4	5
MV06	Wireless Communication Systems	x			Prof. Dr. Stahl	Lect./Lab	4	5
MV08	Digital Signal Processing and Machine Learning	x	x		Prof. Dr. Stichler	Lect./Lab	4	5
MV09	Advanced FEM		x	x	Prof. Dr. Schinagl	Lect./Exerc.	4	5
MV11	Image Processing for automated Production	x	x		Prof. Dr. Wagner	Lect./Lab	4	5
MV15	Selected topics of Polymer Chemistry and Materials Sciences			x	Prof. Dr. Muscat	Lect./Lab	4	5
MV16	Free-Form Surfaces			x	Prof. Dr. Lazar	Lect./Proj.	4	5
MF04	Applied Didactics				offered on demand	Tutorial	2	3
MF10	Electronics Packaging and Manufacturing				Prof. Dr. Winter	Lect./Lab	4	5
MF12	Satellite Navigation				LB Trautenberg	Lect.	4	5
MF20	RF and Microwave Systems				Prof. Dr. Leather	Lect./Exerc.	4	5
MF22	Kalman Filtering in Control Systems and Communications Applications				Prof. Dr. Stichler / Prof. Dr. Mysliwetz	Lect./Exerc.	4	5
MF23	Design of Materials				Prof. Dr. Strübbe	Lect./Exerc.	3	5
MF31	Advanced Design for Additive Manufacturing				Prof. Dr. Riß	Lect./Lab	4	5
MF33	Heat Transfer				Prof. Dr. Stanzel	Lect.	2	3
MG06	Applied numerical methods for mechanical engineering				Prof. Dr. Riß / Prof. Dr. King	Lect./Lab	4	5
MF38	Chemical H2 Conversion: Applications and industrial processes				Prof. Dr. Völkl	Lect./Lab	4	5
MF42	Homogeneous Catalysis				Prof. Dr. Pentlehner	Lect./Lab	4	5
*	AW.0543.M Technical and Business English				Fr. Pötzinger	Lect.	4	5
*	ANG516 Business English				n.n.	Lect.	4	5
**	AW-0 05740.M Deutsch B1.1 / German B1.1				Fr. Edelmann	Lect.	4	5
**	AW-0 05750.M Deutsch B1.2 / German B1.2				Fr. Lembcke	Lect.	4	5
**	AW-0 05760.M Deutsch B2 kompakt / German B2				Fr. Mayr	Lect.	4	5
**	AW-0 05710.M DaF: Kommunizieren und Präsentieren / DaF: Communication and Presentation				Hr. Langsenlehner	Lect.	2	3
RenewEnerg	Renewable Energies				Prof. Stier	Lect.	4	5
MP02	Master's Project						10	12
VHB	Scientific writing				Prof. Dr. Radon, LMU München		2	3
VHB	Medical Image Processing for Diagnostic Applications				Prof. Dr. Maier, Uni Erlangen-Nürnberg		4	5
VHB	Integrated Production Systems				Prof. Dr. Franke, Uni Erlangen-Nürnberg		4	5
VHB	Leadership and Communication in Global Business				Prof. Dr. Winkler, FH Kempten		2	3
VHB	Machine Learning for Engineers I				Prof. Dr. Eskofier, Uni Erlangen-Nürnberg		4	5

* for German students only: will be accepted as MF module (SPO2019 and SPO2016) restricted to a maximum of 5 Credit Points
** for non-German students only: will be accepted as MF module (SPO2019 and SPO2016) restricted to a maximum of 5 Credit Points

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Figure 6: Engineering Sciences Master's Program – Courses expected to be offered in winter term 2023/24 (SPO 20191)

2.2 Courses offered by other departments of the Technical University of applied Sciences

Instead of choosing MF group courses from the Faculty of Engineering Sciences, you can also choose courses which are listed in the following subsections.

Important notice: In any case you also have to submit the following registration form

2.2.1 Courses offered by the Faculty of Informatics: Masterstudium Informatik

The following courses are offered as joint modules for the Master Course Engineering Sciences and for the Masterstudium Informatik. Please note that these modules are taught in German only. Up to 10 Students could apply per email to franz.perschl@th-rosenheim.de for a course. In case of overload in applications, the general rules according §7 Abs. 5 Satz 2 Immatrikulationssatzung apply.

Winter Term:

- Computer Vision
- Embedded Linux
- Systems Engineering

Summer Term:

- Autonome mobile Systeme
- Maschinelles Lernen
- Eingebettete Echtzeitsysteme

Detailed course descriptions are found here

Application for course “Maschinelles Lernen” will not be accepted, if the applicant has taken the course “Grundlagen maschinellen Lernens” during his Bachelor study at TH Rosenheim.

2.2.2 Courses offered by Bavarian Virtual University (Virtuelle Hochschule Bayern)

The following courses may also be granted on request for the master course in engineering sciences. Before you register, please submit the registration form as depicted in the section before.

Winter Term and Summer Term:

- Integrated Production Systems
- Medical Image Processing for Diagnostic Applications
- Scientific writing
- Leadership and Communication in Global Business
- Machine Learning for Engineers I

Here you can get additional information on VHB courses

2.2.3 Courses offered by the language center

The following courses offered by the language center of the Faculty of Applied Natural Sciences and Humanities can be granted as MF-modules. German speaking students can choose the English courses, non-German speaking students are recommended to choose the German language courses. Accreditation is limited to a maximum of 5 Credit Points.

Winter Term and Summer Term:

- Deutsch B1.1 / German B1.1
- Deutsch B1.2 / German B1.2
- Deutsch B2 kompakt / German B2
- DaF: Kommunizieren und Präsentieren / DaF: Communication and Presentation
- Technical and Business English
- Business English

You will find additional information on courses offered by the language center by following this links:

German language courses

English language courses

2.2.4 Elective course offered by Faculty of Management and Engineering

The following course is offered by the Faculty of Management and Engineering. It can be granted as MF module. Winter Term and Summer Term:

- Renewable Energies

Further information can be found here

3 Recommendations for your individual study plan

The master project usually starts at the end of the first semester.

The master thesis usually starts at the end of the second semester.

The order of semesters may be changed if necessary as course contents in all three semesters are independent of each other. Please note that courses are typically held once per year, i.e. either in the spring/summer term or in the fall/winter term.

The following table may be used as a template for planning the three semesters of your master program:

Semester	Modules	CP	CP per Semester
1	1 MG module (mandatory)	5	
	1 MA module (mandatory)	5	
	3 MV module (mandatory)	15	
	Other modules	5	**30**
2	Master project	12	
	1 MG module (mandatory)	5	
	1 MA module (mandatory)	5	
	1 MV module (mandatory)	5	
	Other modules	3	**35**
3	Master thesis	25	**25**

Spring/Summer Term:
Lecture Period: March 15th - approx. July 7th.

Fall/Winter Term:
Lecture Period: October 1st - approx. January 20th.

The examination period in the winter semester is from about January 25th until February 15th, the examination period in the summer semester is typically from about July 5th until July 25th.

4 Remarks on Master´s project and Master thesis

4.1 Declaration of Originality/Eigenständigkeitserklärung

Note that some written documentation (master's project report, coursework) would need a declaration of originality placed immediately after the title page.

Hiermit bestätige ich, dass ich die vorliegende Arbeit selbständig verfasst und keine anderen als die angegebenen Hilfsmittel benutzt habe. Die Stellen der Arbeit, die dem Wortlaut oder dem Sinn nach anderen Werken (dazu zählen auch Internetquellen) entnommen sind, wurden unter Angabe der Quelle kenntlich gemacht.

I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

Place, Date: _____ *Signature:* _____

Figure 7: Declaration of Originality

4.2 Electronic Workflow

The complete process of registration and submission of your thesis is supported by an electronic work- flow. Details can be found at studies-and-further-education

4.3 Guidelines for the preparation of final thesis at the Faculty of Engineering

Before writing your final thesis, consider the **"Guidelines"**

5 Module Descriptions

Module name	Advanced Engineering Mathematics		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MG01	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Schulze	Prof. Dr. Schulze	70% Lecture, 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	30 h	40 h
+ Lab course	**+ Exam preparation**		
0 h	20 h		

Applicability of the module in the degree programmes
Semi-mandatory course in ENG-Master
Recommended prerequisites
Multivariable calculus, ordinary differential equations, integral transforms
Intended learning objectives
Knowledge of important PDE, their origin and fundamental knowledge of solution techniques Acquire the basic theory of the most important PDE (heat-/diffusion, wave- and laplace equation), Gain an overview of and insight in solution techniques for PDE (separation of variables, integral transforms, numerical solutions)

Content

Prerequisites and introduction to PDE

- Surface integrals and integral theorems (Gauss and Stokes theorem)
- Derivation of important PDE
- Boundary conditions

Classical solution methods

- Solution and analysis of the heat- /diffusion equation in one and three variables
- Solution of the wave equation and laplace equation

Numerical methods - Finite differences:

- heat-/diffusion equation and the stability criterion, laplace equation and numerical solution of linear systems of equations
- Finite elements
- Case studies in Matlab/Octave or C

Material

Problem sheets and some lecture notes

Recommended literature

- S.J. Farlow,: Partial Differential Equations for scientists and engineers, Dover Publications, Reprint, 1993
- W.A. Strauss: Partial Differential Equations. An Introduction, Wiley, 2. Edition, 2008

Module name	Electrodynamics		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MG02	null	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Norbert Seliger	Prof. Dr. Norbert Seliger	70% Lecture , 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Mathematics (vector calculus and analysis), Electromagnetic field basics, Matlab/Octave

Intended learning objectives

Specific Goals:
The mathematical and physical principles of classical electrodynamics form the basis of all applications where the interaction of electromagnetic fields with technical systems is of importance, e.g. propagation of electromagnetic waves, antenna theory, electromagnetic compatibility (EMC)
Learning Objectives:

- Fundamental understanding of electromagnetic field theory (static, quasi-stationary and non-stationary fields)
- Computation and analysis of static and time-dependent electromagnetic fields and their application in modern electronic systems
- Introduction to numerical methods and FEM software for the solution of practical electrodynamics problems

Content

- Dipole fields, multipole fields, Potential theory, Coulomb and Lorenz gauge, Maxwell capacitance matrix, Partial and loop inductance, Electromagnetic radiation (retarded potentials), Wave scattering
- Computational Electrodynamics: Method of Moments, Finite Difference Time Domain, Finite Element Method
- Analytical Solution of Laplace equation, e.g. by Fourier series

Material

Lecture notes, worksheets available as download files

Recommended literature

- H. Henke: Elektromagnetische Felder: Theorie und Anwendung, Springer, 2003
- J. D. Jackson: Classical Electrodynamics, Wiley, 3. Edition, 1998
- K. W. Kark: Antennen und Strahlungsfelder: Elektromagnetische Wellen auf Leitungen, im Freiraum und ihre Abstrahlung, Vieweg+Teubner, 2011
- M. N. O. Sadiku: Numerical Techniques in Electromagnetics, CRC Press, 2. Edition, 2000
- M. N. O. Sadiku: Elements of Electromagnetics (Oxford Series in Electrical and Computer Engineering), Oxford University Press, 2006
- D. J. Griffiths: Elektrodynamik, Eine Einführung, Pearson, 3., aktualisierte Auflage, 2011

Module name	Solid State Electronics		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MG03	null	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Popp (I), Prof. Dr. Müller (II)	Prof. Dr. Popp (I), Prof. Dr. Müller (II)	75% Lecture , 25% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	40 h	20 h

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Working principles of electronic devices. Basic know-ledge of the atomic structure of matter and electronic properties of materials. Knowledge of the fundamental mechanisms of interaction.

Intended learning objectives

Specific Goals:

- Enable students to understand the principles of quantum effect devices
- Give insight into fundamentals of nano technology

Content

- Part I (Popp) Fundamental principles of quantum mechanics. Bandgap engineering. Heterostructure devices and quantum effect devices.
- Part II (Müller) Scanning probe microscopy: Working principle, interaction between sample and cantilever, modes of operation (contact, non-contact, tapping, MFM), structuring at a nanoscale. Scanning electron microscopy: Interaction electron beam with matter, EDX. Nano materials: Production methods, properties. Practical lab exercises.

Material

Lecture notes, worksheets available as PDF download

Recommended literature

- R. E. Hummel: Electronic Properties of Materialsg, Springer, 2001
- S. M. Sze: High-Speed Semiconductor Devices, Wiley, 1990
- G. Timp: Nanotechnology, Springer, 1999

Module name	Statistics		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MG04		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Schmiedt	Prof. Dr. Schmiedt	70% Lecture , 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Knowledge of mathematical fundamentals

Intended learning objectives

Specific Goals:
Knowledge of the various statistical methods and a fundamental knowledge of probability calculus.
Learning Objectives:

- Identify stochastic / statistical aspects in every-day processes and issues, especially in technical and economic processes and issues; Gain a broad overview of basic descriptive and explorative methods of statistical data analysis and the possibilities resp. limits of its application.
- Acquire the foundations of probability theory and application of central inductive statistical methods.
- Be able to perform independently data analysis and to apply statistical methods using current statistics software (R). Knowledge and integration of the functionalities and features of popular statistics software packages; Gain the ability to independently acquire stochastic / statistical methods, to evaluate them critically and to implement them in practice using statistics software.

Content

I. Applied Statistics
- introduction
- descriptive and explorative statistics
- univariate analysis
- multivariate analysis
- inductive statistics
- point estimation
- interval estimation
- testing of hypotheses
- linear model

II. Principles of probability calculus

III. Statistics software: Introduction to data analysis with R

IV. Tutorial assignments

- theory and methods
- statistics software (R)

Material

Lecture notes, exercise problem descriptions, R sample programs, demonstration of program results

Recommended literature

- P. Billingsley: Probability and Measure. Anniversary Edition, Wiley, 2012
- S. M. Ross: Introduction to Probability and Statistics for engineers and scientists, Academic Press, 4. Edition, 2009
- J. Tukey: Exploratory Data Analysis, Addison-Wesley, 1977
- W. N. Venables: An Introduction to R, 2014, http://www.cran.r-project.org/doc/manuals/R-intro.pdf

Module name	Fluid Mechanics		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MG05		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F. Buttinger	Prof. Dr. F. Buttinger, Prof. Dr. C. Schäfle	70% Lecture , 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

none

Intended learning objectives

Specific Goals:
The course Fluid mechanics provides a basic introduction in fluid mechanics in theory and practice. Students gain competence in analytical problem understanding and enhance their problem solving capabilities in experiments and with numerical methods. In the computer exercises “CFD-simulations” students improve their skills by using modern computational fluid dynamics (CFD) software programs and they will be able to analyze complex fluid dynamics problems

Content

Fluid mechanics of real flows Fluid mechanics of compressible non-viscous fluids Fluid mechanics of viscous fluids Introduction to CFD simulation Simulation of compressible and incompressible fluids Laboratory experiments and validation of CFD results

Material

Exercise problem descriptions, sample programs, demonstration of program results

Recommended literature

- G. Junge: Einführung in die technische Strömungslehre, Hanser, 2. Auflage, 2015
- H. Kuhlmann: Strömungsmechanik, Pearson, 2. Auflage, 2014
- R. Schwarze: CFD-Modellierung: Grundlagen und Anwendungen bei Strömungsprozessen, Springer Vieweg, 2012

Module name	Applied numerical methods for mechanical engineering		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MG06	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F. Riß	Prof. Dr. F. Riß, Prof. Dr. F. King	100% Lecture	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	30 h	30 h	30 h
+ Lab course	**+ Exam preparation**		
30 h	30 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Engineering mechanics (statics, strength of materials, dynamics), basic knowledge in machine dynamics, mathematic basics (matrix/vector calculus, differential equations)

Intended learning objectives

Specific Goals
Mechanical engineering and CAE tools have a close link to applications, but do not provide any further information about the methods necessary in the background to solve the related engineering problems (every tool is a sort of ‘black box’). On the other hand, classical engineering mathematics is marked with proofs, abstract thinking and no link to any engineering application.
Learning Objectives
Acquire the ability to apply methods of numerical mathematics to solve mechanical problems i.a. form the field of machine dynamics and get a basic understanding of the underlying numerical methods.

Content

- Coordinate transformations,
- numeric matrix calculus and eigenvalue / eigenvector problems,
- solution of higher-dimensional linear and non-linear systems of equations (i.a. from the field of mechanic frame structures),
- numerical solution of problems from machine dynamics or multibody systems (i.a. ordinary differential equations, oscillations of rigid body systems).

Material

Lecture notes, hardcopies and/or PDF download files. MATLAB m-files for lab course.

Recommended literature

- J. Hoffmann: MATLAB und SIMULINK - Beispielorientierte Einführung in die Simulation dynamischer Systeme, Addison-Wesley, 1999
- H. Kerkele, R. Pittschellis: Einführung in die Getriebelehre, Teubner Verlag, 1998
- H. Ulbrich: Maschinendynamik, Teubner Verlag, 1996

Module name	Real-Time Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MA01	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. B. Mysliwetz	Prof. Dr. B. Mysliwetz	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Engineering Sciences Master

Recommended prerequisites

Working principles of microprocessors (IO, interrupts, stack). Programming experience in a blockstructured high level language, preferably ANSI C or C++. Basic knowledge of structure and working principles of a 'general purpose' operating system. Fundamental knowledge of the functional units of a personal computer. Fundamentals of control theory.

Intended learning objectives

Specific Goals:

- To enable students to design and implement software for real-time applications

Learning Objectives:

- Understand the mechanisms and problems associated with real- time applications
- Apply real-time software design rules
- Know the working principles and utilize the services of real-time operating systems, Realize the advantages of using real-time operating systems

Content

Part I - Real-Time Software Design and Real-Time Operating Systems (Mysliwetz) Technical terms and definitions; examples of embedded real-time systems; real-time operating system concepts; processes, threads, tasks; scheduling principles; real-time software design; rate-monotonic scheduling approach; reentrant code; semaphores, mutual exclusion, shared re- sources; synchronization mechanisms; deadlocks; priority inversion; interprocess communication, overview of commercial real-time operating systems; practical laboratory exercises. Lab (Part I) Processes and Threads under Windows; Analysis of Fundamental Real- Time Properties of Windows on a PC; implementing a step motor control application with the real-time kernel uC/OS on an ARM Cortex-M based microcomputer; application of semaphores as a mutual exclusion mechanism while accessing shared resources, effect of priority inversion.
Part II - PC-based Real-Time Control Systems (Schittenhelm) Real-time applications based on personal computers: requirements, hardware and software design, overview and comparison of commercial PC-based systems. Lab (Part II) PC-based real-time systems via OPC-servers; Windows-CE development environment; real-time programming under VxWorks.

Recommended literature

- Lecture notes, worksheets and lab-class problem descriptions available as PDF download files
- Labrosse, J. J: MicroC/OS-II - The Real-Time Kernel, CMP Books, 1999
- Tanenbaum, A. S.: Modern Operating Systems, Prentice Hall, 1992
- Brause, R.: Betriebssysteme - Grundlagen und Konzepte, Springer, 2001
- Iwanitz, F., Lange, J.: OPC Fundamentals, Implementation and Application, Hüthig-Verlag, 2006
- Stallings, W.: Operating Systems: Internals and Design Principles, Prentice Hall, 2014

Module name	Integrated Circuit System Design and Test		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MA02	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. H. Thurner	Prof. Dr. H. Thurner	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Familiarity with digital logic and switching circuits; basic knowledge of a high level programming language.

Intended learning objectives

Specific Goals:
Part I:
To enable students to design complex digital circuits (ASICS or FPGAs) and systems using architecture optimization at RTL level, different synthesis steps and system simulation
Part II:
To enable students to verify and test IC systems and to use test system
Learning Objectives:
Part I

- Understanding the fundamentals of digital VLSI (or SoC) circuit design methodology.
- Optimizing architecture design at RTL level using equivalent transforms for combinational and sequential computations
- Design digital VLSI (or SoC) circuits using appropriate design tools to determine and optimize a RTL level architecture, to verify the model behavior by simulation and to synthesize the model into a FPGA.

Part II:
Understand the fundamental problems associated with fail observation and analysis. Use of test systems and design for test methods to ensure system debug and product engineering

Content

Part I - Design of Digital Integrated VLSI Circuits Design methodology: modelling behaviour and structure using different levels of abstraction. Design flow, synchronous design. Architecture design and optimization at RTL level: Data dependency graph, isomorphic architecture, equivalent transforms for combinational computations, equivalent transforms for non-recursive sequential computations, unfolding of recursive sequential loops for LTI and linear time variant systems.
Part II - Test of Integrated Systems: Basic Function of Integrated Circuits, Failure and Defect Models, Observing and Detecting Failures, Fundamentals of Digital Test, Hardware Test Setups.

Material

Part I: Lecture notes, problem sheets and lab-class problem descriptions Part II: Problem sheets and lab-class problem descriptions

Recommended literature

- Lecture notes, problem sheets and lab-class problem descriptions, Problem sheets and lab-class problem descriptions
- H. Kaeslin: Digital Integrated Circuit Design, Cambridge University Press, 2008
- J. Segura, C. F. Hawkins: How it Works, How it Fails, IEEE Press, 2004
- -: Training Tutorial of the Hilevel Griffin System, Hilevel Technology Inc., 2005

Module name	Mixed Signal Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MA03	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F. Stubenrauch	Prof. Dr. F. Stubenrauch	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Good knowledge of the representation of continuous and time discrete signals in the time and frequency domain; fundamentals of digital signal processing, analogue and digital circuit design.

Intended learning objectives

Specific Goals:

- To enable students to design mixed signal systems in a professional manner with respect to the properties of real world data converters Assess the properties of data converters as given in the corresponding data sheets in order to select appropriate components for a mixed signal application
- Evaluate the properties of data converters and mixed signal systems by measurement and hardware characterization
- To enable students to design mixed signal systems in a professional manner with respect to the properties of real world data converters

Learning Objectives:

- Understand the fundamental problems associated with analogue to digital and digital to analogue conversion in real world mixed signal systems
- Assess the properties of data converters as given in the corresponding data sheets in order to select appropriate components for a mixed signal application
- Evaluate the properties of data converters and mixed signal systems by measurement and hardware characterization

Content
Fundamentals of data conversion, discrete and fast Fourier transform including the use of windows, analogue and quantization noise, voltage references, static and dynamic properties of data converters, fast ADC and DAC architectures, mixed signal design guidelines
Material
Book like lecture notes and problem sheets including detailed solutions
Recommended literature
• Book like lecture notes and problem sheets including detailed solutions • M. J. Demler: High Speed Analog to Digital Conversion, Academic Press, 1991 • D. F. Hoeschele: Analog to Digital and Digital to Analog Conversion Techniques, Wiley, 1994 • W. Kester et al.: High Speed Design Techniques, Analog Devices Inc., 2010 (http://www.analog.com/en/technical-documentation/resources/index.html) • W. Kester et al.: Mixed Signal and DSP Design Techniques, Analog Devices Inc., 2009 (http://www.analog.com/en/technical-documentation/resources/index.html) • R. A. Pease: Troubleshooting Analog Circuits, Newnes, 1991 • H. Zumbalen: Linear Circuit Design Handbook, Analog Devices, 2008 • -: Training Tutorial of the Hilevel Griffin System, Hilevel Technology Inc., 2005

Module name	Selected Topics in Assembly Technology		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MA04	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. C. Meierlohr	Prof. Dr. C. Meierlohr	60% Lecture, 20% Exercise, 20% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	70 h	15 h	10 h
+ Lab course	**+ Exam preparation**		
40 h	15 h		

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Knowledge in assembly and manufacturing processes and assembly organization

Intended learning objectives

Specific Goals:

- Have in-depth knowledge in selected joining processes, in using specialized equipment for material supply and in applying state-of-the-art methods for planning assembly systems

Learning Objectives:

- Have in-depth knowledge in selected joining techniques and procedures
- Have in-depth knowledge in selected technologies and equipment for assembly
- Be able to carry out the design of assembly systems with special attention to current strategies and planning methods, Have knowledge about and be able to optimize existing assembly systems

Content

- Bonding with adhesives: material-fit based assembly
- Design for assembly
- Handling processes and equipment for automated assembly
- Use of 3D-human-simulation for assembly planing
- Hybrid assembly: human-robot-collaboration
- Manual assembly: worker assistance
- System design with lean manufacturing

Material

Lecture notes and lab-class problem descriptions available as PDF download files

Recommended literature

- Lecture notes,
- S. Hesse: Grundlagen der Handhabungstechnik, Carl Hanser, 4. Auflage, 2016
- T. Jüntgen: Klebtechnik – klebgerechte Konstruktionen und Anwendungen in der Praxis., Vogel Communications Group, 1. Auflage, 2018
- T. Jüntgen: Klebtechnik – klebgerechte Konstruktionen und Anwendungen in der Praxis., Vogel Communications Group, 1. Auflage, 2018
- B. Lotter: Montage in der industriellen Produktion, Springer, 2. Auflage, 2012
- G. Spur: Handbuch Fügen, Handhaben und Montieren, Carl Hanser, 2013
- A. Wolf: Grippers in Motion – The Fascination of Automated Handling Tasks, Carl Hanser, 2018

Module name	Model-Based Development		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MA05	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F. Perschl	Prof. Dr. F. Perschl	75% Lecture, 25% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	45 h	30 h	15 h
+ Lab course	**+ Exam preparation**		
15 h	45 h		

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Basic knowledge of Matlab/Simulink/Stateflow; Basic knowledge of control theory

Intended learning objectives

Specific Goals:

- In this lecture students will get profound knowledge about many aspects of model based development of embedded systems and state-of-the-art development methods in various industries like automotive, aerospace and consumer industries.
- Also, the students will learn to apply basic aspects of modelling and simulating dynamic systems with TheMathworks tool chain.
- Furthermore they will learn how to use the dSpace tool chain for rapid control prototyping and code generation for embedded systems.

Learning Objectives:

- Students will know and be able to use modern software development methods for embedded systems.
- Students will be able to solve problems in the field of control of mechatronic, mechanical or electronic systems with the help of simulation, rapid control prototyping and deploying to real hardware.
- Students will learn to use Mathworks and dSpace tools.

Content

- Definition and basics of model based development
- Basics on modelling dynamic systems with Simulink
- dSPACE tool chain (RTI, ControlDesk, Hardware)
- Aspects of real-time programming / multivariate control
- Modelling of discrete states with Stateflow
- Advanced modelling techniques

Material

Lecture notes

Recommended literature

- A. Angermann, M. Beuschel, M. Rau, U. Wohlfarth: Matlab Simulink - Stateflow, De Gruyter Oldenbourg, 10. Auflage, 2020
- H. Lutz, W. Wendt: Taschenbuch der Regelungstechnik mit Matlab und Simulink, Europa Lehrmittel, 12. Auflage, 2021
- TheMathworks: Matlab documentation
- dSpace: HelpDesk
- Prof. Dr.-Ing. Franz Perschl: Model-Based Development, Lecture notes
- Prof. Dr.-Ing. Franz Perschl: Model-Based Development, Lab Course descriptions

Module name	Materials from Renewable Resources		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MA06	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. J. Schroeter	Prof. Dr. J. Schroeter	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Semi-mandatory course in ENG-Master

Recommended prerequisites

Chemistry; Material Science

Intended learning objectives

Specific Goals:

- Goals Provide knowledge about materials, whose biomass feedstocks are provided by nature annualy.

Learning Objectives:

- Learning Objectives Definitions History of mankind’s use of materials from renewable resources (MFRR) Present impact Survey of materials

Content

- Statutes, standards, guidelines, certification History of mankind’s use of MFRR (wood, natural fibres, leather, rubber, colourants)
- Present impact for the environment and for sustainable feedstock supply Survey of materials available (plastics/ non-plastics/ additives)
- Life cycle analysis

Material
Lecture notes, worksheets available as download files

Recommended literature
• D. Kaplan: Biopolymers from renewable resources, Springer, 1998 • T. Scheper (ed.): Biopolyesters. Advances in biochemical engineering/ Biotechnology. Vol. 71., Springer, 2001 • H. Endres, A. Siebert-Raths: Technische Biopolymere, Hanser, 2009 • D. Fengel, G. Wegener: Wood: Chemistry, Ultrastructure, Reactions, de Gruyter, 1984 • M. Belgacem, A. Gandini: Monomers, Polymers and Composites from Renewable Resources, Elsevier, 2008

Module name	Microelectronics		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF01	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Popp	Prof. Dr. Popp	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Working principles of semiconductor devices. DC- and AC-description of MOS- and bipolar-devices. Basic familiarity with SPICE-modelling.

Intended learning objectives

Enable students to understand the principles of full custom design and fabrication of integrated circuits

Content

Lecture Semiconductor technology (layer growth, doping, masking, mounting). MOS- and BIP- Circuit integration, layout-rules, dimensioning with typical examples. Lab class On-wafer measurements of MOSand BIP-devices and circuits. Electrical characterisation, SPICE-parameter extraction. Mounting and bonding of a small IC. Layout exercises. SPICE-simulations.

Recommended literature

- N. Weste, K. Eshragian: Principles of CMOS VLSI Design, Addison Wesley, 1994
- S. M. Sze: VLSI Technology, John Wiley, 1990

Module name	Applied Didactics		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF04	-	ING M1-3	3
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. W. A. Mayr	dependent on module	100% Lecture	2
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	German or English, in agreement with the responsible professor / teacher
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
60 h	30 h	28 h	h

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Excellent professional skills of the subjects, the student has to teach. This course 'Applied Didactics' can be chosen only in agreement with the professor / teacher, who is responsible for this lab class or exercise.

Intended learning objectives

A deeper understanding of selected basic engineering topics ('learning by teaching') and of didactic concepts in engineering education.

Content

Depends on selected course for tutorial

Recommended literature

- Depends on selected course for tutorial

Module name	Electronic Packaging and Manufacturing		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF10	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. M. Winter	Prof. Dr. M. Winter	80% Lecture, 10% Exercises, 10% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	50 h	30 h	20 h
+ Lab course	**+ Exam preparation**		
10 h	40 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Knowledge of analysis and design of analog circuits.

Intended learning objectives

Specific Goals

Students shall get an overview and understanding about packagaging technologies used for electronic devices as ICs and sensors and the impact of each technology on the system performance and reliability. Furthermore the students should be enabled to integrate electronic devices on system level (second-level assembly).

Learning Objectives

- Understand basics of material science involved in electronic packaging with focus on reliability
- Common technologies for mounting integrated circuits and sensor chips on carriers and for providing electrical interconnections.
- Technologies for substrate configuration, component assembly technology and encapsulation including relevant application examples from state-of-the-art development for consumer and automotive products like MEMS sensors (pressure sesors, gas sensors, microphones).
- The students should be able to identify and to assess the interdependencies between chip design, miniaturization issues, system performance and packaging technology.
- Understanding of common failure modes and method for defect analysis (X-ray, CT-scan, ultrasonic microscope, mechanical grinding)

Content

Challenges and definitions of microelectronics packaging, IC and MEMS sensors backend manufacturing processes, first-level packaging:

- Integrated circuit packaging, sensor packaging and interconnection
- Lead frames, die bonding
- Wire bonding
- Flip Chip Technology (FC)
- Chip Size Packages (CSP)
- Wafer Bonding (WB)
- Through Hole Technology (THT)
- Area array packages
- Ball Grid Arrays (BGA)
- Substrates: Organic substrates, Single and multilayer printed circuit boards , Multilayer cofired ceramic technology (HTCC and LTCC)
- Polymers
- Encapsulation: Molding, Glob Top
- Second-level packaging: board assembly processes
- Surface Mount Technology (SMT)
- Third level: Interconnects and switches
- basics of involved material science
- manufacturing processes

Material

Lecture notes, multimedia presentations

Recommended literature

- R. Tummala: Fundamentals of Microsystem Packaging, McGraw-Hill, 2. Edition, 2019
- C. Harper: Electronic Packaging and Interconnection Handbook, McGraw-Hill, 4. Edition, 2004

Module name	Satellite Navigation		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF12	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Holger Stahl	Dr. Hans L. Trautenberg	50% Lecture, 50% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	30 h	60 h	30 h

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Basic linear algebra, analysis and statistics. Basics of electrodynamics (wave propagation). Proficiency in a programming language to solve homework problems (mostly linear algebra problems)

Intended learning objectives

Specific Goals
To enable students to assess the applicability of satellite navigation for a given problem
Learning Objectives

- Understand the principles of satellite navigation
- Know the limitations of satellite navigation

Content

History of satellite navigation, positioning methods, description of orbits, range measurements with CDMA techniques, signal propagation in ionosphere and troposphere, multi path and interference problems, user equivalent range error budget and link budgets, system architecture of satellite navigation systems, GPS overview, Galileo overview, integrity of position solutions, integrity of navigation systems, implementation of navigation algorithms.

Material

Lecture notes

Recommended literature

- E. D. Kaplan: Understanding GPS Principles and Applications, Artech House Publisher, 3. Edition, 2017
- B. W. Parkinson, J. J. Spliker: Global Positioning System: Theory and Applications, American Institute of Aeronautics and Astronautics, 1996
- G. Strand, K. Borre: Linear Algebra, Geodesy, and GPS„ Willesly-Cambridge Press, 1997
- B. Hofmann-Wellenhof, H. Lichtenegger, J. Collins: GPS Theory and Practice, Springer, 5. Edition, 2012

Module name	Power Electronic Circuit Design		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF14	-	ING M1-3	3
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. N. Seliger	Prof. Dr. N. Seliger	70% Lecture, 30% Exercises	2
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
90 h	30 h	15 h	30 h

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Knowledge in power electronics, electrical circuits, semiconductor devices, Python/LTSPICE basics

Intended learning objectives

- Design of complex power electronic circuits based on specifications. Ability to select the proper topology and calculate and simulate (Python, LTSPICE) voltage and current transients in power semiconductor elements and passive components. Layout rules for power electronic circuits. Cooling solutions, thermal management. Interfacing with digital signal processing.

Content

- Electrical Design: Topology Selection, Circuit Design, Losses in Power Semiconductors, Power Passives (Inductors, Transformers, Capacitors), Simulation (Python, LTSPICE), Layout, Isolation Coordination
- Thermal Design: Thermal Impedance, Thermal Management, Reliability Issues, Case studies and Lab experiments

Material

Lecture notes, worksheets available as PDF downloads

Recommended literature

- N. Mohan: Power Electronic Circuits, Wiley, 2003
- R. Erickson: Fundamentals of Power Electronics, Springer, 3. Edition 2020
- W. Yang: Circuit Systems with MatLab and PSPICE, Wiley, 2008
- I. Batarseh: Power Electronic Circuits, Wiley, 2. Edition, 2018

Module name	RF and Microwave Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF20	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. P.S.H. Leather	Prof. Dr. P.S.H. Leather	50% Lecture, 50% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	30 h	30 h	25 h

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Knowledge in power electronics, electrical circuits, semiconductor devices, Python/LTSPICE basics

Intended learning objectives

1. Develop an overall picture of radio and microwave systems, primarily for communications.
2. Understand performance requirements and how they relate to system specifications.
3. Learn about various transceiver architectures, their merits and costs.
4. Derive system specifications from wireless communication standards.
5. Calculate an end-to-end link budget, develop a level plan and create system-level behavioural models.

Content

1. Modulation, Transmitters and Receivers Receiver, transmitter and transceiver architectures RF signals Analogue and digital modulation Interference and distortion Early receiver technology Modern transmitter architectures Modern receiver architectures
2. Antennas and the RF Link RF antennas Radiation from a current filament Resonant antennas Travelingwave antennas Fundamental antenna parameters The RF link Radio link interference
3. RF Systems Broadcast, simplex, duplex, diplex and multiplex Cellular communications Multiple access schemes Spectrum efficiency Cellular phone systems Generations of radio 4G, fourth generation radio: beyond 3G and LTE family 5G, fifth generation radio: beyond 4G

Material

The course is based mainly on reference A, in particular chapters 2-4. Additional material may also be sourced from references B-G. Students should be able to derive their notes from course lectures.

Recommended literature

- M. Steer: Microwave and RF Design, Volume 1: Radio Systems, NC State University, 3. Edition, 2019
- H. De Los Santos: Radio Systems Engineering, Springer, 2015
- W. Egan: Practical RF System Design, Wiley, 2003
- C. Bowick: RF Circuit Design, Newnes, 2007
- J. B. Hagen: Radio-Frequency Electronics, Cambridge, 1996
- K. M. Gharaibeh: Non-linear Distortion in Wireless Systems, Wiley, 2012
- L. Smaïni: RF Analog Impairments Modeling for Communication Systems Simulation, Wiley, 2012
- E. McCune: Practical Digital Wireless Signals, Cambridge, 2010

Module name	Kalman Filtering in Control Systems and Communications Applications		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF22	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. B. Mysliwetz, Prof. Dr. M. Stichler	Prof. Dr. B. Mysliwetz, Prof. Dr. M. Stichler	25% Lecture, 75% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	0 h	30 h	60 h
+ Lab course	**+ Exam preparation**		
30 h	30 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Familiarity with MATLAB and C (or C++) programming. Course MV01 Advanced Control Systems is strongly recommended. Passing of assessment test is required for admission.

Intended learning objectives

Specific Goals
Enable students to understand the working principles and application areas of recursive estimation methods and to design and implement numerically efficient and stable algorithms for state and parameter estimation.
Practial implemementation and analysis is done within a lab project
Learning Objectives

- Know application areas of state and parameter estimation approaches
- Understand central working principles and algorithms of recursive estimation methods
- Be aware of potential numerical problems and the computational load of different mathematical formulations of KF algorithms
- Gain hands-on application experience in KF design, filter tuning and embedded implementation

Content

- Introduction Background, Motivation and Application Fields of Kalman Filtering
- Mathematical Fundamentals Matrix Algebra Basics, Linear Systems Theory, Discretization
- Probability Theory Fundamentals Random Variables, Stochastic Processes, White Noise
- State Space Model of a Dynamic System Continuous-Time vs. Discrete Time, State Observer, Observability
- Least Squares Estimation
- Propagation of States and Covariances
- The Discrete-Time Kalman Filter
- Alternate Filter Formulations Factorization, Square Root Filters, Nonlinear/Extended Kalman Filter
- Special Topics Resolving Numerical/Stability Problems, Filter Tuning
- Practical Lab Projects/Exercises e.g.: Positionand Motion-Estimation from Image Pro- cessing Data, Carrier Phase Recovery in a Receiver/Demodulator, Position- and Motion- Estimation for Inertial Navigation

Material

Lecture notes, worksheets and lab-class problem descriptions available as PDF download files

Recommended literature

- D. Simon: Optimal State Estimation. Kalman, H Infinity, and Nonlinear Approaches, Wiley, 2006
- B. P. Gibbs: Advanced Kalman Filtering, Least-Squares and Modeling: A Practical Handbook, Wiley, 2011

Module name	Design of Materials		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF23	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Norbert Seliger	Prof. Nicole Strübbe	66% Lecture, 33% Lab course	3
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	30 h	20 h	h
+ Lab course	**+ Exam preparation**		
60 h	40 h		

Applicability of the module in the degree programmes
Technical elective course in ENG-Master
Recommended prerequisites
Basic course in polymer chemistry and extrusion
Intended learning objectives
Specific Goals The students should learn how to design/achieve specific needed material properties, e.g. corrosion protection, scratch resistance, low shrinkage in thermoplastics, elastomers as well as in paints and coatings. Learning Objectives To gain the knowledge and competence how to use fillers and additives in plastics or how to create material combinations (plastic - plastic, wood - plastic, metal - plastic, etc) to achieve enhanced material/composite properties.

Content

- Definition of terms: additives, pigments, fillers
- Additives in General*Polymer Compounds
- Fillers: Classification of Fillers, Particle morphology of Fillers, Fillers and their function, Rules of Mixtures, Effect of Filler, Form of Filler, Dispersing and Grinding, Interaction between particles
- Methods for particle incorporation
- Extrusion
- Dissolver
- Triple roll mill
- High Speed agitator ball mill
- Application examples and recipes in thermoplastics, paints and coatings and elastomers
- Methods for testing specific filler properties e.g. color, oil absorption;
- Methods for testung specific application properties e.g. scratch resistance, corrosion protection;

Material

Creation of own extruder screw configuration Lecture notes, worksheets and lab-class problem descriptions available as PDF download files

Recommended literature

- Ceresana: Füllstoffe, Market Study, 2016
- J. C. J. Bart: Additives In Polymers: Industrial Analysis And Applications, Wiley, 2005
- D. Gysau: Füllstoffe, Vincentz Network, 3. überarbeitete Auflage, 2014
- P. Eyerer, T. Hirth, P. Elsner: Polymer Engineering, Springer, 2008
- M. Xanthos: Functional Fillers for Plastics, Wiley, 2. Edition, 2010
- D. Walter, Deutsche Forschungsgemeinschaft (DFG): Nanocomposites: Primary Particles – Agglomerates – Aggregates, Wiley, 2013
- J. Winkler: Dispergieren von Pigmenten und Füllstoffen, Vincentz Network, 2010
- Hoffmann Mineral GmbH: www.hoffmann-mineral.com

Module name	Ceramics and other Sintering materials		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF24	-	ING M1-3	3
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Müller	Prof. Dr. Müller	50% Lecture, 50% Lab course	2
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
90 h	15 h	15 h	15 h
+ Lab course	**+ Exam preparation**		
15 h	30 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Intended learning objectives

Enable students to understand the specific properties and production methods of ceramic materials and the resulting different appications

Content

- powders: properties and production methods
- feedstock composition
- forming technologies
- sintering
- mechanical properties: KIc, Weibull-Statistics, life-time prediction
- oxide-ceramics
- non-oxide-ceramics
- functional ceramics
- lab-course: manufacturing of ceramics according different methods, determination of properties

Module name	Experimental modeling and simulation		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF30	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Zentgraf	Prof. Dr. Zentgraf	100% Lecture	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	0 h	15 h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

no formal Prerequisites, but recommendations are from mathematics linear differential equations, Laplace transformation, vector algebra and MATLAB/Simulink

Intended learning objectives

Specific Goals
methods to describe physical systems mathematically, coding the methods into MATLAB/Simulink, checking of program inputs and outputs
Learning Objectives
modelling of physical systems applied to real simple and complcated systems, self-coding of the methods from bottom up and evaluating of results (no click-and-look usage of existing programs)

Content

Principals of physical modelling, experimental meodelling methods, coding of the methods, checking of the methods, application of the methods on real, non-trivial systems

Material

Lecture notes

Recommended literature
• J. Crassidis, J. Junkins: Optimal Estimation of Dynamix Systems, Chapman & Hall/CRC, 2004

Module name	Advanced Design for Additive Manufacturing		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF31	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Riß	Prof. Dr. Riß	100% Lecture	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
90 h	30 h	0 h	15 h
+ Lab course	**+ Exam preparation**		
30 h	15 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

CAD, FEM, Lightweight design

Intended learning objectives

Specific Goals
Designing parts dedicated to additive manufacturing
Learning Objectives
Getting the ability to take the full potemtial of AM parts based on applying the right way of desinging additive manufacturing parts

Content

- introdution in additive manufacturing
- Product development for Additive Manufacturing
- design rules

Material

Lecture notes

Module name	Intellectual Property Protection		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF32	-	ING M1-3	3
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
LB Hermann Wagner	LB Hermann Wagner	100% Lecture	2
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
90 h	30 h	0 h	15 h
+ Lab course	**+ Exam preparation**		
30 h	15 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

none

Intended learning objectives

- The students get an introduction to the use of ideas for their technical product developments
- They learn the basics fort he successful registration and defense of their industrial property right
- They can research and evaluate property rights in databases and assess their importance for their own applications;
- They can prepare patent applications for their inventions

Content

- Overview of the industrial property rights patent, utility model, design and trademark;
- search methods for industrial property rights;
- formulation and registration of industrial property rights;
- effect and scope of protection of industrial property rights;
- appeal for industrial property rights;
- measures against infringements of property rights;
- economic significance and utilization of property rights (innovations management);
- inventor rights for employees;
- copyright in the field of science and technology

Material

lecture notes available as download files

Recommended literature

- lecture notes
- www.dpma.de
- www.epo.org
- www.wipo.int

Module name	Heat Transfer		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF33	-	ING M1-3	3
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. S. Stanzel	Prof. Dr. S. Stanzel	70% Lecture, 30% Exercises	2
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
90 h	30 h	30 h	15 h

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

basic principles of heat transfer mechanisms and basics of fluid mechanics, partial differential equations

Intended learning objectives

Specific Goals
Knowledge and application of heat transfer mechanisms with regard to technical applications
Learning Objectives
Know heat transfer mechanisms and assign them to technical applications, solve heat transfer problems, analyze applications with regard to heat transfer

Content

- heat conduction: steady state and transient, one dimensional and selected multidimensional, with different boundary conditions
- heat transfer by convection and radiation
- applications: fin design, heat exchanger design

Recommended literature

- J. H. Lienhard: A Heat Transfer Textbook, Phlogiston Press, 2019

Module name	Trajectory Planning for Robots and Automatic Machines		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF36	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. King	Prof. Dr. King	60% Lecture, 20% Exercises, 20% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	50 h	30 h	30 h
+ Lab course	**+ Exam preparation**		
20 h	20 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

Fundamentals of linear algebra (vectors, matrices, coordinate systems). Fundaments of control engineering and Fourier analysis.

Intended learning objectives

Specific Goals

- Enable students to generate desired paths and trajectories for robots and multi-axes mechatronic systems.
- Analyze the resulting trajectory with regard to its basic properties and the tendency to generate oscillations.

Learning Objectives

- Describe robots and other mechatronic systems with one or more axes with regard to the kinematic structure using multiple coordinate systems.
- Generate different types 1D desired trajectories for the movement of 1D systems.
- Generate path and trajectory for Cartesian and point-to-point movement of robots and multi-axes systems as an input to the servo control system. Simulate, visualize and analyze the generated trajectories and paths using Matlab.

Content

- Necessary fundamentals of robotic theory: introduction to robotics, kinematics (translational, rotational). Introduction to trajectory and path planning.
- 1D trajectory planning: basic motion profiles, composition of motion profiles, multi-point trajectories, dynamic analysis of trajectories.
- Multi-dimensional trajectories and path planning: point-to-point movement based on motion profiles, Cartesian movement in 2D and 3D space including orientation interpolation.

Material

Lecture notes, worksheets and lab course problem descriptions available as PDF for download; Matlab files to demonstate examples.

Recommended literature

- R.N. Jazar: Theory of Applied Robotics, Springer, 2010
- L. Biagiotti, C. Melchiorri: Trajectory Planning for Automatic Machines and Robots, Springer, 2008

Module name	Chemistry of renewable resources		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF37	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. List / Prof. Dr. Pentlehner	Prof. Dr. List / Prof. Dr. Pentlehner	75% Lecture, 25% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	45 h	30 h	40 h
+ Lab course	**+ Exam preparation**		
15 h	20 h		

Applicability of the module in the degree programmes
Technical elective course in ENG-Master
Recommended prerequisites
basic knowledge in chemistry
Intended learning objectives
Specific Goals overview and knowledge about the chemistry of renewable resources. Different types of resources, pathways, applications. Learning Objectives definitions, advantage and disadvantages compared to fossil raw materials, pathways for renewable resources, applications

Content

- Biorefinary: from renewable resources to chemicals and pharmaceeuticals
- Chemical modifications of chemicals from renewable resources, e.g. Celluloseacetate, …
- Bulk chemicals from renewable resources"
- Biopolymers
- Fats and oils
- Carbohydrates
- Lignin
- Amino acids and proteins
- Others, e.g. terpenoids, vitamins"

Material

lecture notes available as download files

Recommended literature

- specific literature for each chapter

Module name	Chemical H2 Conversion: Applications and industrial processes		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF38	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Völkl	Prof. Dr. Völkl	50% Lecture, 25% Exercises, 25% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	30 h	30 h	30 h
+ Lab course	**+ Exam preparation**		
30 h	30 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

basic knowledge in chemistry, thermodynamics and (process) modelling

Intended learning objectives

Specific Goals
Students should get in-depth knowledge of Hydrogen conversion processes
Learning Objectives

- Understand the different routes for Hydrogen conversion based on desired products and origin of hydrogen
- Understand the material cycle of the chemical industry and bring this in context to new developments
- Compare different routes based on economical and sustainability quality parameters
- Analyze the different proceses to get all reactants for the conversion processes beside Hydrogen
- Deepen the understanding of Hydrogen conversion processes by working on an individual case study of a selected example of a Hydrogen conversion process"

Content

- overview of Hydrogen conversion processes
- overview of the material cycle of the chemical industry
- overview of different sources for all important components of the material cycle
- Introduction of economical and sustainability performance indicators
- Comparision of different routes of hydrogen conversion processes
- Individual case study on a selected example of a hydrogen conversion process

Material

lecture notes available as download files

Recommended literature

- Specific literature for each chapter, current papers.

Module name	International Master Summer School		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF39	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F. Perschl	Prof. Dr. F. Perschl	50% Lecture, 25% Exercises, 25% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	40 h	50 h	20 h
+ Lab course	**+ Exam preparation**		
20 h	20 h		
Applicability of the module in the degree programmes			
Technical elective course in ENG-Master			
Recommended prerequisites			
Basic knowledge in 3D-CAD			

Intended learning objectives

Specific Goals

- Basic concept of this course is to transmit short overviews and insights into today´s tools and methods transitioning fast to practical examples in personal exercises and workshops. The examples origin from actual situations or compressed typical situations in industrial use.
- Students gain basic knowledge on Additive Manufacturing Technologies. Based on practical design and manufacturing lessons in the workshop, all participants get in direct contact with the total process chain.

Learning Objectives

- understand and experience data analysis methods and practical use of artificial intelligence
- transfer the ideas of Lean Management to different corporate sectors of producing units
- classify and evaluate occurring industrial situations into change and future proof concepts
- obtain insights into the concept of emission trading and its challenges
- develop an understanding of what does it take to be a successful leader in international setting.
- Understand the basic terminology and processes of Additive Manufacturing
- utilize methods in design for layer-wise technology
- recognize the complete end-to-end process
- understand the challenges of designing parts and operating machines.

Content

- Digital Technologies
- Artificial Intelligence Basics
- Lean Managment
- EU Emissions Trading
- Gear Design
- Additive Production Technology
- Construction of parts
- Manufacturing
- Quality Management
- Post-Processing
- Assembly and Testing"

Recommended literature

- F. Balsliemke, A. Behrens: Einstieg in Lean Administration, Springer Gabler, 2019
- F. Bertagnolli: Lean Management: Einführung und Vertiefung in die japanische Management-Philosophie, Springer Gabler, 2.Auflage, 2020
- A. Burgess: The Executive Guide to Artificial Intelligence, Palgrave Macmillan, 2018
- T. Kollmann: E-Business, Springer Gabler, 7.Auflage, 2019
- S. Radzevich: Dudley's Handbook of practical gear design and manufacture, CRC Press, 2016
- D. Whetten, K. Cameron: Developing Management Skills, Pearson, 9.Auflage, 2015
- I. Gibson: Additive manufacturing technologies - 3D printing, rapid prototyping, and direct digital manufacturing, Springer, 2015
- O. Diegel, A. Nordin, D. Motte: A Practical Guide to Design for Additive Manufacturing, Springer, 2020
- A. Gebhardt: Understanding additive manufacturing - rapid prototyping, rapid tooling, rapid manufacturing, Hanser, 2011

Module name	Homogeneous Catalysis		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF42	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Völkl	Prof. Dr. Völkl	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	30 h	30 h	40 h
+ Lab course	**+ Exam preparation**		
30 h	20 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

profound knowledge in chemistry

Intended learning objectives

Specific Goals

- overview and knowledge about the catalytic methodes in chemistry, e.g. hetergenous, homogeneous, transition metal catalysis or organocatalysis. Understanding of the working principle (reaction mechanism) of homogeneus catalysist. Ability to run experiments under inert atmosphere.

Learning Objectives

- definitions, advantage and disadvantages compared to other cataylic methods. Reaction mechanisms and experimental setups for homogenoeus catalysis.

Content

- overview catalytic methods
- organometal-chemistry and transition metal catalysis
- organocatalysis
- stereoselective reactions
- Photocatalysis

Material
lecture notes available as download files
Recommended literature
• specific literature for each chapter • E. Breitmaier, G. Jung: Organic Chemistry, Thieme, 7.Auflage, 2012

Module name	Techno-economic Analysis and Simulation		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MF43	-	ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Völkl	Prof. Dr. Völkl	50% Lecture, 25% Exercises, 25% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	30 h	30 h	30 h
+ Lab course	**+ Exam preparation**		
30 h	30 h		

Applicability of the module in the degree programmes

Technical elective course in ENG-Master

Recommended prerequisites

basic knowledge in chemistry, chemical engineering and (process) modelling

Intended learning objectives

Specific Goals
Students should get in-depth knowledge of the conduction of techno-economic evaluations supported by process simulation
Learning Objectives

- Understanding how to carry out Techno-Economic Analysis
- Comparing different process routes based on Techno-Economic criteria
- Understanding how to obtain all required data
- Deepening the understanding in the application of Simulation for process development and process evaluation

Content

- Fundamentals of economical process assessment: How to calculate CAPEX and OPEX and use those values to derive corresponding criteria
- Comparison of different cost estimation approaches
- Application of evaluation methods for sustainability criteria, e.g. greenhouse gas emissions
- Overview of methods of conceptual process design
- Comparison of different approaches for a Techno-Economic evaluation of process routes
- The theoretical background of the content of the module is applied in exercises and computer courses throughout the semester

Material

lecture notes available as download files

Recommended literature

- specific literature for each chapter

Module name	Advanced Control Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV01		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F.A. King	Prof. Dr. F.A. King	60% Lecture, 20% Exercises, 20% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	50 h	30 h	30 h
+ Lab course	**+ Exam preparation**		
20 h	20 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Classical control theory in frequency domain. Vector and matrix fundamentals.

Intended learning objectives

Specific Goals:

- Enable students to design modern control systems
- Analyse state-space systems and design controllers/observers by use of numeric tools

Learning Objectives

- Apply state-space descriptions to control systems
- Analyse a system's stability, controllability and observability
- Design state space controllers and state observers by pole placement and optimal control
- State-space system analysis and controller/observerdesign using Matlab

Content

State Space Control:

- State space description, solutions for the state-space equations, analysis of state-space description (stability, controllability, observability).
- State-space controller design, controller structure, computation of the pre-filter, computation of the controller matrix using pole placement and optimal control.
- State observer structure and design.

Material

Lecture notes, worksheets and lab-class problem descriptions available as PDF download files

Recommended literature

- R. C. Dorf, R. H. Bishop: Modern Control Systems, Pearson, 14. Auflage, 2021
- G. F. Franklin, J. D. Powell, A. Emani-Naeini: Feedback Control of Dynamic Systems, Pearson, 8. Auflage, 2019
- K. Ogata: Modern Control Engineering, Pearson, 5. Auflage, 2009

Module name	Industrial Process Control		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV02		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. K. Krämer	Prof. Dr. K. Krämer, Prof. Dr. F. Perschl	70% Lecture, 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Basics of sensor applications in automation technology. Knowledge of electrical / pneumatic drives and actuators. Experience in designing logic and sequential controllers. Basics of safety rules and safety devices in industrial automation.

Intended learning objectives

Specific Goals:

- To enable students to design and implement solutions in industrial automation.
- Give insight into fundamentals and specific knowledge in CNC-machinery and CNC-programming as well as in designing logical and sequential control
- Give an overview about higher-level industrial process control components

Learning Objectives

- Evaluate different devices and methods with focus on the different technical parts, Develop CNC-control programs as well as more complex PLC programs
- Analyse and structurize CNC and PLC systems, select the right system(s) for the planned surrounding
- Calculate the costs of installation and maintenance of automation plants

Content

Part II (Perschl):

- Structure and operation of a PLC system (SIMATIC S7).
- Hardware configuration. Overview of programming languages.
- Programming sequential control functions.

Industrial communication. Edge and cloud computing. Data exchange over heterogenous networks. Industrial Internet of Things (IIoT).

Material

Lecture notes, worksheets and lab course descriptions available as download files. Videos, PPT-presentations, PC-simulations.

Recommended literature

- Siemens Industry Automation Translation Services: Dictionary of Electrical Engineering, Power Engineering and Automation, Publicis MCD / Siemens, 5th edition, 2003
- D. Schmid: FESTO didactic: Dictionary of Control Technology Automatisierungstechnik mit Informatik und Telekommunikation, EUROPA Lehrmittel, 5. Auflage, 2002
- H. Berger: Automating with SIMATIC, Publicis MCD / Siemens, 6. Auflage, 2016
- W. Kriesel, O. W. Madelung: The AS-Interface for Automation, Hanser, 2. Auflage, 1999
- Phoenix Contact: Industrial Communication, PPT Presentation1, Chapt 1-7
- R. Isermann: Mechatronische Systeme, Springer, 2. Auflage, 2007
- T. Marlin: Process Control: Designing processes and control systems for dynamic performance, Mac Graw Hill, 2. Auflage, 2000
- J. Daxl, G. Kurz, W. Schachinger: Grundlagen über numerisch gesteuerte Werkzeugmaschinen (CNC), Jugend & Volk, 2. Auflage, 2004
- H. B. Kief, H. A. Roschiwal: CNC-Handbuch 2009/2010, Hanser, 2009
- S. Suk-Hwan: Theory and Design of CNC Systems, Springer, 2008
- P. Smid: CNC Programming Handbook, Industrial Press, 3. edition, 2007

Module name	Servo Drive Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV03		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. R. Hagl	Prof. Dr. R. Hagl	70% Lecture, 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Basic knowledge in electrical drives, closed loop control, and MATLAB/ Simulink

Intended learning objectives

Specific Goals:
Enable students to design and commission motion control systems with electromechanical and direct driven servo drives. Optimization of motion profile, controller parameters regarding reference and disturbance behavior, and contouring behavior.
Learning Objectives
Knowledge of static and dynamical behavior of different drive components and their interaction. Functional principles of motion controllers, including feed forward and filters. Specific characteristics of digital motion controllers. Optimization of parameter setting of motion controller. Understanding of field oriented control for 3-phase AC-motors without and with field weakening. Influence of position measuring devices. Usage of simulation and engineering tools e.g. MATLAB and Simulink.

Content

Static and dynamical requirements for servo drives. Control structures and motion profiles. Motion control of stiff drive systems, including influence of sampling time and processing dead time. Simulation and engineering tools. Motion control of elastic drive systems. Feed forward and filters. Practical courses for drive simulation. Dynamical models of DC and AC drives including field oriented control. Interaction of motor and mechanics. Influence of axis controllers on contouring behavior. Influence of position measuring devices. Practical exercises with servo drive systems.

Material
Scipt for lecture and practical course

Recommended literature
• A. Binder: Elektrische Maschinen und Antriebe, Springer, 2012 • R. Fischer: Elektrische Maschinen, Carl Hanser, 17.Auflage, 2017 • J. Pollefliet: Electronic Power Control, Volume 2: Electronic Motor Control, Academia Press, 2011 • D. Schröder: Elektrische Antriebe – Grundlagen, Springer, 5.Auflage, 2013

Module name	Automation Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV04		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. C. Meierlohr	Prof. Dr. C. Meierlohr	50% Lecture, 30% Exercises, 20% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	40 h	30 h	40 h
+ Lab course	**+ Exam preparation**		
20 h	20 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Fundamental knowlegde on automation of manufacturing processes, basic knowledge on industrial robots

Intended learning objectives

Specific Goals:
To enable students to design and apply state-of-the-art automation systems for industrial manufacturing systems.
Learning Objectives

- Know details on the design and plannig procedure for automated manufacturing systems
- Simulating and programming an industrial robot
- Apply safety aspects and doing a risk-analysis according to legal standards
- Model and operate automated manufacturing systems using simulation methods

Content

- Flexible automation, planning procedures
- Safety regulations and equipment
- Interlinking, buffers, workpiece carriers
- Process simulation for design and optimization
- Commissioning and operating of automated systems, process capability and OEE
- Industrial robots as important element for automated manufacturing

Material

Lecture notes and lab-class problem descriptions available as PDF download files

Recommended literature

- Lecture Notes
- E. Dietrich: Abnahme von Fertigungseinrichtungen, Hanser, 4. Auflage, 2019
- M. Flocke: Steigerung der Anlagenproduktivität durch OEE-Management – Definitionen, Vorgehen und Methoden — von manuell bis Industrie 4.0, Springer, 2018
- S. Hesse: Grundlagen der Handhabungstechnik, Hanser, 4. Auflage, 2016
- S. Hesse: Grundlagen der Handhabungstechnik, Hanser, 4. Auflage, 2016
- Pilz: The Safety Compendium – For the application of functional safety standards, Pilz GmbH & Co. KG, 2017
- G. Reinhart: Industrieroboter – Planung, Integration, Trends : ein Leitfaden für die KMU, Vogel, 2018

Module name	Reliability of Mechatronic Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV05		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. M. Versen	Prof. Dr. M. Versen	70% Lecture, 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Statistics

Intended learning objectives

Specific Goals:
To enable students to evaluate mechatronic systems under the aspects of reliabilty
Learning Objectives

- Know different failure models
- Apply virtual qualification methods based on robustness validation concept
- Plan a test scenario for a give model, Setup/design reliable systems

Content

- Failure Modes, Defects &Testing of CMOS ICs, power devices, passive devices and electronic packaging, Fail Rate Models
- ESD, Reliability Analysis on case studies, e.g. ESD
- Test planning, Use of Redundancy and Monitors

Material

Lectures notes and hardcopies and/or PDF download files for seminar class preparation

Recommended literature

- A. Meyna, B. Pauli: Zuverlässigkeitstechnik, Hanser, 2. Auflage, 2010
- J. Segura, C. F. Hawkins: CMOS Electronics, How it Works, How it Fails, IEEE Press, 2004
- S. Voldman: ESD Physics and Devices, Wiley, 2004
- J. Lutz: Semiconductor Power Devices, Springer, 2011
- A. Birolini: Reliability Engineering Theory and Practice, Springer, 2010
- J. McPherson: Reliability Physics and Engineering, Springer, 2010

Module name	Wireless Communication Systems		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV06		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. H. Stahl	Prof. Dr. H. Stahl	67% Lecture, 33% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	22 h	24 h
+ Lab course	**+ Exam preparation**		
24 h	20 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Fundamentals of System Theory, Digital Modulation and Communication Protocols

Intended learning objectives

Specific Goals:

- Understanding the structure and the underlying transmission techniques of selected current wireless communication systems and networks.
- Analysis and assessment of services, components, and protocols of wireless networks.

Learning Objectives

- In this course, two or three different modern mobile communciation and wireless broadcast systems are explained in a holistic manner. Most current wireless standards use the transmistion principles OFDM (Orthogonal Frequency Division Multiplex) or OFDM-A, which will be explained thoughly during the class.
- After a very short (90 min) review of the prerequistite knowledge, the course treats some fundamentals of wireless and mobile communication.
- In the main part of this class, examples for communication and broadcast systems are treated. The matter is taught both theoretically, and practically in form of interactive class queries and acompanying lab exercises.

Content
Lecture: Basics of wireless communication: Propagation and link budget; cellular systems; 4G mobile communication: LTE; Digital Video Broadcasting DVB-T2). Lab Class with Hands-on Exercises: Spectrum overview; DVB-T channel and signal analysis; LTE RF Measurements and Protocol Analysis
Material
Lecture notes, worksheets and lab-class instructions are available electronically
Recommended literature
• M. Sauter: Grundkurs Mobile Kommunikationssysteme UMTS, HSDPA und LTE, GSM, GPRS und Wireless LAN, Vieweg+Teubner, 2011 (available in German as eBook) • S. Sesia, M. Baker, I. Toufik: LTE – The UMTS Long Term Evolution: From Theory to Practice, Wiley, 2011 • C. Gessner: Long Term Evolution – A concise introduction to LTE and its measurement requirements, Rohde&Schwarz, 2011 • W. Fischer: Digitale Fernseh und Hörfunktechnik in Theorie und Praxis, Springer, 2016 (available in German as eBook) • W. Fischer: Digital Video and Audio Broadcasting Technology, Springer, 2010

Module name	Advanced Digital Communications		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV07		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. M. Stichler	Prof. Dr. M. Stichler	70% Lecture, 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Basics of system theory and digital signal processing

Intended learning objectives

Understanding of the basics of digital communication systems; concepts of modern digital communication systems: OFDM and CDMA.

Content

- Lecture Basics of digital communication systems: Modulation, mobile communication channel, time variant multi-path propagation, demodulation, synchronization, channel estimation and equalization. Concepts of modern mobile communication systems: OFDM, basics, synchronization, equalization. CDMA, basics, synchronization, equalization.
- Lab Class Simulation of methods and algorithms used in digital communication systems with tools like e.g. MatLab

Material

Lecture notes, worksheets and lab class handouts are available in hardcopy and PDF

Recommended literature

- B. Sklar: Digital Communications, Fundamentals and Applications, Prentice Hall, 2000
- J. G. Proakis: Digital Communications, McGraw Hill, 2001

Module name	Digital Signal Processing and Machine Learning		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV08		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. M. Stichler	Prof. Dr. M. Stichler	70% Lecture, 30% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	60 h	30 h	20 h

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Fundamentals of system theory

Intended learning objectives

Advanced knowledge in applied digital signal processing with view on applications in the areas of information and communication technology as well as control technology

Content

- Lecture Deterministic and stochastic signals and systems, discrete Fourier- and Wavelet-Transformation, LTI systems, design and implementation of digital systems, sample rate conversion, multirate signal processing.
- Lab class Design, simulation (using MatLab and/or Simulink) and implementation of simple algorithms on digital signal processors (DSPs) and/or FPGAs.

Material

Overhead, board, beamer

Recommended literature

- A. Oppenheim, R. Schafer: Discrete-Time Processing, Pearson, 3. Edition, 2009
- V. K. Ingle, J. G. Proakis: Digital Signal Processing using Matlab, Brooks/Cole, 2000
- J.H. Chow, D. K. Frederick, N. W. Chbat: Discrete-Time Control Problems using Matlab, Brooks/Cole, 2003

Module name	Advanced FEM		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV09		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. S. Schinagl	Prof. Dr. S. Schinagl	60% Lecture, 20% Exercises, 20% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	36 h	30 h	30 h
+ Lab course	**+ Exam preparation**		
24 h	30 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Engineering Mechanics (Statics, Strength of materials, Dynamics), FEM basics

Intended learning objectives

Specific Goals:
To enable students to evaluate structures and components with respect to their mechanical behavior and reliabilty
Learning Objectives

- analyse nonlinear structural mechanic problems considering all kinds of nonlinearities (geometry, material, contact)
- work in the field of modal based linear structure dynamical analyses
- strength verification

Content

- Fundamentals of numerical modeling and analysis of nonlinear structural problems Modal based linear dynamics: Natural frequencies and mode shapes, frequency response analysis / harmonic analysis, response spectrum analysis
- Strength verification: Influence factors on static strength and fatigue strength, concepts of strength verification with local stresses

Material

Lecture notes and hardcopies and/or PDF download files

Recommended literature

- C. Gebhardt: Praxisbuch FEM mit ANSYS Workbench: Einführung in die lineare und nichtlineare Mechanik, Hanser, 2011
- FKM Guideline: Analytical Strength Assessment of Components, VDMA Verlag, 2013
- J. A. Collins: Failure of Materials in Mechanical Design, Wiley, 2nd ed, 1993
- J. A. Bannantine, J. J. Comer, J. J. Handrock: Fundamentals of Metal Fatigue, Prentice Hall, 1990

Module name	Electromagnetic Compatibility		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV10		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. N. Seliger	Prof. Dr. N. Seliger	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Knowledge in electromagnetic fields, transmission lines, electrical signals and circuit components

Intended learning objectives

Specific Goals:
Within this lecture students will learn the basics of EMC engineering and its application in early system design. By discussing case studies and lab experiments we will bridge the gap between theory and practical implementation.
Learning Objectives

- Understanding of basic aspects of EMC: theory of emission and reception of conducted and radiated electro-magnetic interference signals, coupling mechanisms and their models. Design methods and techniques for EMC compliance: PCB and circuit design, grounding, filter design, signal spectra, system design, shielding aspects.
- EMC measurement techniques and EMC standards

Content

- Introduction to EMC and EMI phenomena, Basic concepts (conducted and radiated emission and susceptibility)
- Electrical signals and their spectra, Propagation and crosstalk, coupling, EMC modeling
- Interference control techniques (PCB and circuit design, shielding, grounding, filter design), EMC measurements and EMC Standards, Case studies and Lab experiments

Material

Lecture notes and problem sheets

Recommended literature

- C. Paul: Introduction to EMC, Wiley, 2006
- H. Ott: EMC Engineering, Wiley, 2009
- J. Franz: EMV: Störungssicherer Aufbau elektronischer Schaltungen, Springer Vieweg, 5.Auflage, 2013
- C. Christopoulos: Principles and Techniques of EMC, CRC Press, 2.Auflage, 2007
- M. Montrose, E. Nakauchi: Testing for EMC Compliance, Wiley, 2004
- A. Schwab: Elektromagnetische Verträglichkeit, Springer, 2007
- S. Dhia, M. Ramdani, E. Sicard: EMC of Integrated Circuits, Springer, 2006

Module name	Image Processing for Automated Production		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV11		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. M. Wagner	Prof. Dr. M. Wagner	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Familiarity with basic matrix calculations

Intended learning objectives

Specific Goals:
Students will be enabled to

- select suitable hardware components for a given imaging problem
- calibrate the optical system
- design, test and optimize the network of imaging operators by using a GUI imaging toolkit
- create a graphical user interface
- establish a complete industrial application by generating sequences for operator execution and data exchange

Learning Objectives
During this course, students will gain knowledge in:

- Types of cameras, data formats, optics, illuminations
- two dimensional algorithms in image enhancement, extraction and localization of features, classification of features
- 2d and 3d transformations
- 2d and 3d camera calibration
- creation of industrial imaging applications by using a GUI (graphical user interface) imaging toolkit

Content

- Camera types, image- and data formats, optics, illuminations, optical filters.
- Binary image morphology.
- Image enhancement: Noise reduction filters, grey value scaling, thresolding.
- Digital Fast Fourier Transform (DFFT).
- Extraction of edges and ridges.
- Pattern matching.
- Shape analysis.
- Hough Transform and Generalized Hough Transform (GHT) for object localization.
- Classifiers, especially Neural Network Classifiers.
- Texture analysis.
- 2d transforming of images and masks.
- 2d camera calibration, internal and external camera parameters.
- 3d camera calibration.
- 3d object localization.
- 3d line section based surveying.

Material

Lecture notes and problem sheets

Recommended literature

- S. Theodoridis, K. Koutroumbas: Pattern Recognition, Elsevier, 2009
- E. R. Davies: Machine Vision - Theory, Algorithms, Practicalities, Elsevier, 2005
- C. Steger, M. Ulrich, C. Wiedemann: Machine Vision Algorithms and Applications, Wiley, 2.Auflage, 2018

Module name	Mechanical Design		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV12		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. M. Wagner, Prof. Dr. M. Neumaier	Prof. Dr. I. Ragai, Prof. Dr. M. Wagner	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		
Applicability of the module in the degree programmes			
Specialization subject in ENG-Master			
Recommended prerequisites			
A minimum of 15 credits in mechanical drawing, calculation of geometric tolerances, CAD			

Intended learning objectives

Specific Goals:
The students will have a practical knowledge of and ability to develop, design and optimize technical, mainly mechanical products in a conflicted area of complex requirements. The students will have experience in project management.
Learning Objectives
Various complex design tasks are given to student teams. The teams have to plan and execute the development and design tasks independently under supervision of professors and engineers. Depending on the task, the teams use supporting tools and methods for mechanical design such as

- advanced CAD (free form surface, sheet metal design, motion assembly)
- DFMA (Design for Manufacturing and Assembly) method
- FEM (Finite Element Method)
- creative design methodologies
- industrial design basics
- arithmetic and statistical tolerance calculations
- project management
- prototyping and testing

At the end, all product documents are to be submitted and a final pre-sentation is to be given in a concluding seminar meeting.

Content

- Design methodologies
- Optimizing for assembly and manufacturing
- Design project management
- Advanced design tools
- Product documentation
- Tolerance calculations

Material

Literature in the library and on the internet, standards, patents, software, tools and methods (DFMA, CAD, FEM, statistical tolerance calculation)

Recommended literature

- Pahl et. al.: Engineering Design: A Systematic Approach, Springer, 3rd edition, 2007
- VDI-Guideline 2221

Module name	Advanced light weight construction		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV13		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Riß	Prof. Dr. Riß	60% Lecture, 20% Exercises, 20% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	36 h	30 h	30 h
+ Lab course	**+ Exam preparation**		
24 h	30 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Engineering Mechanics (Statics, Strength of materials, Dynamics), FEM basics; Manufacturing basics, Material Science basics

Intended learning objectives

Specific Goals:
Within this lecture students will learn the basics of lightweight design topics (combination of structural lightweight design, manufacturing lightweight design and material lightweight design) and getting to know how to apply this.
Learning Objectives

- Understanding the basic effect of lightweight design: lightweight design approaches, assessment and selection of lightweight designs, methods and rules for lightweight design parts, standard elements for lightweight design (shell, lattice, honeycomb,…)
- Learning the basics of manufacturing for lightweight design: manufacturing technologies, limits
- Understanding the basics of lightweight materials: kind of material, selection of material, pros and cons

Content

Introduction in the topic of lightweight design, terminology, basic mechanical engineering topics for lightweight design, lightweight design approaches (for example: topology optimization), manufacturing technology dedicated to lightweight design, materials for lightweight design, analysis and calculation of lightweight design parts, bionic design, lightweight design standards, lessons learnt from practical application, case studies and lab exercises

Material

Lecture notes and hardcopies and/or PDF download files

Recommended literature

- H.-P. Degischer, S. Lüftl: Leichtbau - Prinzipien, Werkstoffauswahl und Fer-tigungsvarianten, Wiley, 2009
- L. J. Gibson, M. F. Ashby: Cellular solids, Cambridge University Press, 2st ed.,1997
- B. Klein: Leichtbau-Konstruktion - Berechnungsgrundlagen und Gestaltung, Vieweg + Teubner, 8. Aufl.,2009
- C. Mattheck: Design in der Natur, Rombach, 4. Aufl.,2006
- C. Mattheck: Verborgene Gestaltgesetze der Natur, Karlsruher Institut für Technologie, 2006
- W. Nachtigall: Bau-Bionik - Natur, Analogien, Technik, Springer, 2003
- J. Wiedemann: Leichtbau, Springer, 3. Aufl.,2007

Module name	Advanced injection molding		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV14		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. M. Würtele	Prof. M. Würtele	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	German
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	30 h	30 h	h
+ Lab course	**+ Exam preparation**		
60 h	30 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Bachelor course injection molding

Intended learning objectives

Learning off Machine and processing technology for standard injection molding and also for special processes and learning to project injection molding plants

Content

- Materials for injection molding, Injection molding Machines, Injection molding processing
- Calculations for projecting
- Special process technologies

Recommended literature

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Module name	Selected topics of Polymer Chemistry and Materials Sciences		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV15		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. D. Muscat	Prof. Dr. D. Muscat / Dr. Schmid	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes
Specialization subject in ENG-Master

Recommended prerequisites
none

Intended learning objectives
Part I The first part introduces the different types of caoutchoucs and their nomenclature. Typical examples are explained. The vulcanization of caoutchoucs and the production of tires as the major example in the rubber field are discussed. Besides classical rubbers new polymer networks based on pericyclic reactions are introduced. Therefore, first the Diels Alder reaction is explained and then the use of this reaction in polymeric networks is reagarded. For a better understanding of the analysis of plastics an overview of applied techniques is given and some examples are discussed in detail. Part II Understanding the reactions of organic Peroxides as radikcal sources. Including safe handling with organic peroxides. Application of organ. peroxides for the modification of polymers. Explanation of the radical reactions for crosslinking, grafting and curing, as well as for the PP-degradation. This from an application-technical point of view.

Content

Part I : Caoutchoucs, Plastics, Reaction-mechanisms Understanding

1) types and production of caoutchoucs, vulcanization and production of rubbers
2) novell networks based on pericyclic reactions (Diels Alder reactions)
3) analysis of Plastics

Part II : Peroxide modification of polymers

1) Radikal initators – Use and reactions (Organic peroxides)
2) Safe handling of organic peroxides
3) Crosslinking of polyolefines and elastomers
4) Vis breaking of polymers (i. e. PP degradation)
5) Monomer grafting onto polymers6) Curing of unsaturated polyesters

Recommended literature

- H.G.Elias: Makromoleküle Band 1:Chemische Struktur und Synthesen, Wiley-VCH, 6.Auflage, 1999
- H.G.Elias: Makromoleküle Band 2:Physikalische Strukturen und Eigenschaften, Wiley-VCH, 6.Auflage, 2000
- J. Lahann: Click Chemistry for Biotechnology and Materials Science, Wiley, 2009
- E. Baur, S. Brinkmann,T. Osswald, N. Rudolph, and E. Schmachtenberg: Saechtling Kunststoff Taschenbuch, Hanser, 31. Aufl.,2013
- W. Hellerich, G. Harsch, E. Baur: Werkstoff-Führer Kunststoffe Eigenschaften - Prüfungen – Kennwerte, Hanser, 10. Auflage,2010

Module name	Freeform-Surfaces		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV16		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. M. Lazar	Prof. Dr. M. Lazar	50% Lecture, 50% Lab course	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
150 h	60 h	15 h	h
+ Lab course	**+ Exam preparation**		
60 h	15 h		

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

Knowledge of mathematical fundamentals 3D-CAD

Intended learning objectives

Specific Goals:

Goals Knowledge of principles in the development of products with freeform surfaces Learning Objectives

- Mathematic background of curves and surfaces
- Methods of designing freely shaped objects
- Methods of manufacturing freely shaped objects
- Inspection of freely shaped objects

Learning Objectives

- Mathematic background of curves and surfaces
- Methods of designing freely shaped objects
- Methods of manufacturing freely shaped objects Inspection of freely shaped objects

Content

- Mathematical Background (Bezier Curves, B-Splines, NURBS)
- CAGD: Introduction to shape design with CATIA
- Scanning Technologies, Reverse Engineering, CAD-CAM and 5-axes Machining, Rapid Prototyping

Material

Lecture notes, Software: CATIA, CAMWorks, Colin3D

Recommended literature

- L. Piegl, W. Tiller: The NURBS Book, Springer, 1997
- G. Farin, J. Hoschek, M.-S. Kim: Handbook of Computer Aided Geometric Design, Elsevier, 2002

Module name	Mechanical Transmission		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MV17		ING M1-3	5
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. Doleschel	Prof. Dr. Doleschel	80% Lecture , 20% Exercises	4
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	summer Semester	Englisch
Total workload	**= Presence**	**+ Self-study**	**+ Exam preparation**
150 h	80 h	20 h	40 h

Applicability of the module in the degree programmes

Specialization subject in ENG-Master

Recommended prerequisites

basic course in mechanical design

Intended learning objectives

Specific Goals:

- design capability on typical gear box types (spur gears, worm gears, bevel gears), on lubrication
- calculation methods

Content

- Gear design
- Gear failure analysis
- Analysis of industrial and automotive systems

Material

Lecture notes

Recommended literature

- S. Radzevich: Dudley's Handbook of practical gear design and manufacture, CRC Press, 3. Edition 2016

Module name	Master’s project		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MP01	-	ING M1-3	12
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F. Perschl	Professor as advisor	100 % Lab course	18
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter & summer term	English
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
360 h	0 h	0 h	h
+ Lab course	**+ Exam preparation**		
360 h	0 h		

Applicability of the module in the degree programmes

Mandatory subject in ENG-Master

Recommended prerequisites

none, but some projects require competences from specialization modules

Intended learning objectives

To learn to apply project management methods and to train team working skills; in a close-to-real-life situation students shall experience what it means to systematically analyze and plan a project, to organize themselves and to cooperate in a team and to deliver results within the planned deadline.

Content

- Case study project that typically deals with a real-world problem assigned by industry or proposed by professors; project is carried out by a team of 4-6 students and coached by one or two professors.
- The project has to be carried out in the laboratories of the university

Material

project related

Recommended literature

- project related

Module name	Master Thesis		
Number(s)	**Abbreviation**	**Curriculum semester**	**ECTS**
MP02	-	ING M1-3	25
Responsible for the module	**Lecturer(s)**	**Teaching form**	**SWS**
Prof. Dr. F. Perschl	2 professors as advisors	100 % Lab course	24
Form of examination	**Module duration**	**Module rotation**	**Language**
See SPO	1 Semester	winter & summer term	English/German
Total workload	**= Presence**	**+ Self-study**	**+ Exercise preparation**
750 h	0 h	0 h	h
+ Lab course	**+ Exam preparation**		
720 h	30 h		

Applicability of the module in the degree programmes
Mandatory subject in ENG-Master
Recommended prerequisites
none
Intended learning objectives
Final project at an engineer's qualification level; carried out by an individual student on his/her own with two professors as advisors either at Rosenheim University of Applied Sciences or at an industrial company
Content
Depending on student's selection and availability
Material
project related
Recommended literature
• project related