Hochschule
für angewandte Wissenschaften
Würzburg-Schweinfurt
Faculty of Electrical Engineering
Faculty of Mechanical Engineering

Module Handbook for the Bachelor's Degree Programme

Mechatronics

Modulhandbuch für den Bachelorstudiengang

Mechatronics

Hochschule
für angewandte Wissenschaften
Würzburg-Schweinfurt

B.Eng. Programme Mechatronics

Ignaz-Schön-Str. 11

97421 Schweinfurt

Basis: Study and Examination Regulations for the Mechatronics Bachelor's degree programme (SPO IMC) in the version dated 21st June 2017 / 19th November 2019

Contents

Vorbemerkung

Das vorliegende Modulhandbuch beinhaltet Beschreibungen aller Module, welche durch Studierende im Rahmen des Bachelorstudiengangs Mechatronics (IMC) an der Hochschule für angewandte Wissenschaften Würzburg-Schweinfurt zu absolvieren sind.

Grundsätzlich sind die Modulbeschreibungen in der Sprache erstellt, in welcher die Veranstaltung stattfindet und im Normalfall auch die Prüfungsleistung gemäß Studien- und Prüfungsordnung abzuleisten ist.

Um die Konflikte zwischen verschieden Abkürzungen zu vermeiden, werden auch im englischen Text die Abkürzungen benutzt, die im deutschen Hochschulsystem üblich sind. Als Beispiel ist hier die Verwendung der Abkürzung SWS (Semesterwochenstunden) als Ersatz für den englischen Begriff „credit hours“ zu erwähnen. Weitere Abkürzungen sind in der Übersichtstabelle erklärt.

Preliminary Note

This handbook contains description of all the modules of the bachelor’s degree programme Mechatronics (IMC) at the University of Applied Sciences Würzburg-Schweinfurt.

In principle, the module description for a module is compiled in the language, which is, in accordance with the study and examination regulations, the language of instruction and examination for that module.

In order to avoid conflicts caused by different abbreviations, the standard German university abbreviations are also used in English descriptions. For example, credit hours are represented by the German term SWS (Semesterwochenstunden). Further abbreviations are explained in the modules overview table.

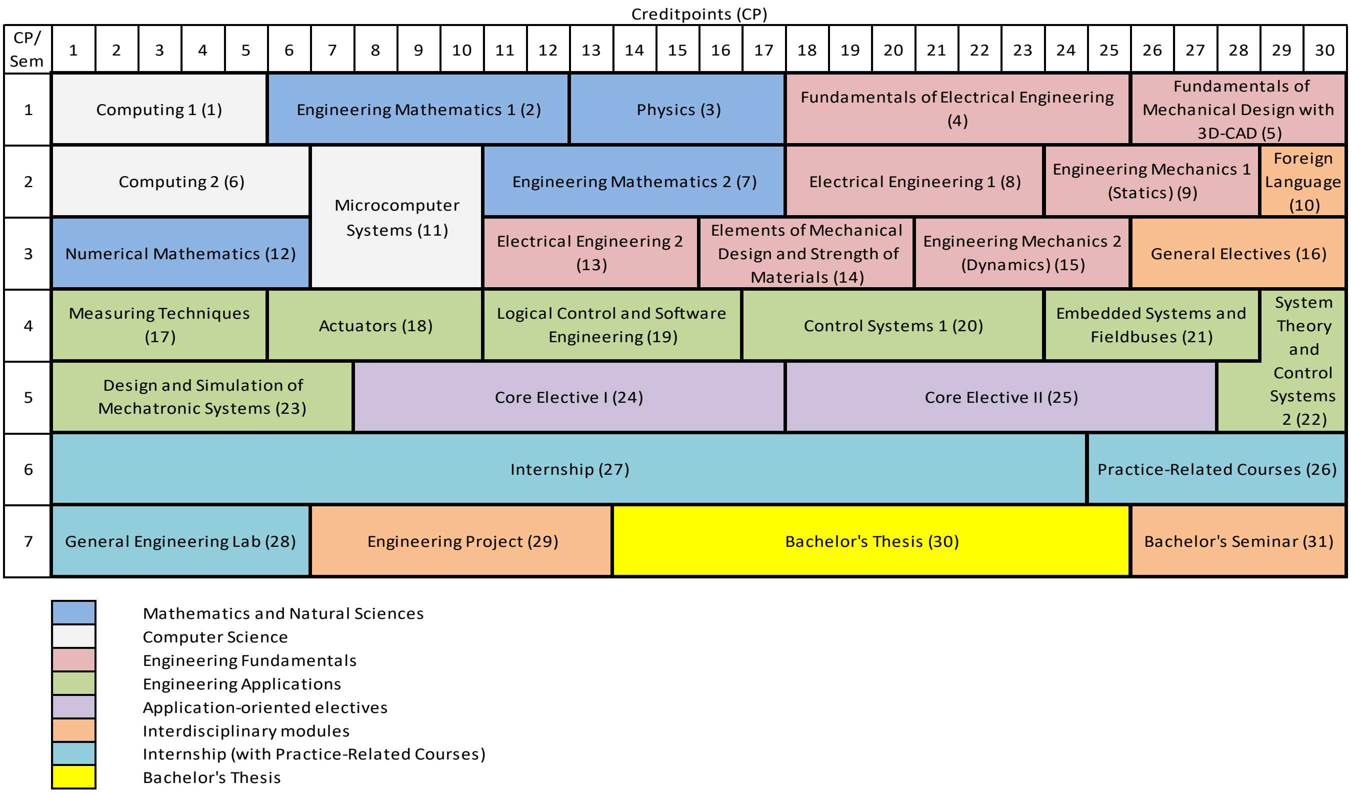
1 Study Plan and Matrix of Learning Objectives

1.1 Study Plan for the Mechatronics Bachelor's Degree Programme

The study plan for the Mechatronics Bachelor's degree programme is described in three variants:

- Graphical representation of the course of studies regarding Credit Points (CP) and therefore students' workload
- Graphical representation of the course work regarding contact hours (SWS) and thus the students' expected attendance time
- Tabular representation of modules and courses with information about assignment to the programme semester and the examination situation

Structure and modular organisation of the programme in Credit Points (CP)



Courses & attendance time, expressed in contact hours (SWS)

Credit hours (CH) / in German: Semesterwochenstunden (SWS)

CH/ Sem	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	Computing 1 (1)				Engineering Mathematics 1 (2)						Physics (3)				Fundamentals of Electrical Engineering (4)						Fundamentals of Mechanical Design with 3D-CAD (5)						
2	Computing 2 (6)					Microcomputer				Engineering Mathematics 2 (7)						Electrical Engineering 1 (8)						Engineering Mechanics 1 (Statics) (9)				Foreign Language (10)	
3	Numerical Mathematics (12)				Systems (11)			Electrical Engineering 2 (13)				Elements of Mechanical Design and Strength of				Engineering Mechanics 2 (Dynamics) (15)				General Electives (16)							
4	Measuring Techniques (17)				Actuators (18)				Logical Control and Software Engineering (19)					System Theory and Control Systems 2 (22)		Control Systems 1 (20)						Embedded Systems and Fieldbuses (21)					
5	Design and Simulation of Mechatronic Systems (23)					Core Elective I (24)										Core Elective II (25)											
6	Practice-Related Courses (26)																										
7	General Engineering Lab (28)					Engineering Project (29)				Bachelor's Seminar (31)																	

Blue	Mathematics and Natural Sciences
Light grey	Computer Science
Pink	Engineering Fundamentals
Green	Engineering Applications
Purple	Application-oriented electives
Orange	Interdisciplinary modules
Turquoise	Internship (with Practice-Related Courses)

Overview of the modules in table form

Appendix: **Module overview for the degree programme Bachelor of Mechatronics (English-language programme) at the University of Applied Sciences Würzburg-Schweinfurt**
Effective from 1 October 2017

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
							Examinations					Weighting	
No.	Exam number/ Module ID	Module name	Semester	SWS	CP	Teaching Format	Type	Length / Format	Language	Final grade	Admittance to exam depends on	Weighting factor	Actual weight
1	CMP1	Computing 1	1	4	5	SU, LPr	soP (m.E./o.E.)	H	English	no		0	0
2	MA1	Engineering Mathematics 1	1	6	7	SU, Ü	sP	90-180 min	English	yes		0,5	3,5
3	PHY	Physics	1	4	5	SU, Ü, LPr	sP	90-120 min	English	yes		0,5	2,5
4	FEE	Fundamentals of Electrical Engineering	1	6	8	SU, Ü	sP	90-180 min	English	yes		0,5	4
	FMD	Fundamentals of Mechanical Design with 3D-CAD								yes			
5	CADLab	3D-CAD Lab	1	1	5	LPr	soP (m.E./o.E.)	H	English	0%		0,5	2,5
	MD	Fundamentals of Mechanical Design		3		SU, Ü	sP	90-120 min		100%			
6	CMP2	Computing 2	2	5	6	SU, LPr	sP	90-180 min	English	yes	CMP1	0,5	3
7	MA2	Engineering Mathematics 2	2	6	7	SU, Ü	sP	90-180 min	English	yes		0,5	3,5
8	EE1	Electrical Engineering 1	2	6	6	SU, Ü	sP	90-180 min	English	yes		0,5	3
9	EM1	Engineering Mechanics 1 (Statics)	2	4	5	SU, Ü	sP	90-120 min	English	yes		0,5	2,5
10	FL	Foreign Language	2	2	2	[1]	[1]		[1]	yes		0,5	1
11	MCS	Microcomputer Systems	2 / 3	4 / 3	8	SU, Ü, LPr	sP	90-180 min	English	yes		1	8
12	NM	Numerical Mathematics	3	4	6	SU, Ü, LPr	sP	90-180 min	English	yes		1	6
13	EE2	Electrical Engineering 2	3	4	5	SU, Ü	sP	90-120 min	English	yes		1	5
14	EMDSM	Elements of Mechanical Design and Strength of Materials	3	4	5	SU, Ü	sP	90-120 min	English	yes		1	5
15	EM2	Engineering Mechanics 2 (Dynamics)	3	4	5	SU, Ü	sP	90-120 min	English	yes		1	5
16	GE	General Elective	3	4	5	[1]	[1]		[1]	yes		1	5
17	MT	Measuring Techniques	4	4	5	SU, LPr	sP	90-120 min	English	yes		1	5
18	ACT	Actuators	4	4	5	SU, LPr	sP	90-120 min	English	yes		1	5
19	PLCSE	Logical Control and Software Engineering	4	5	6	SU	sP	90-180 min	English	yes		1	6
	CS	Control Systems 1								yes			
20	CS1Lab	Control Systems Lab 1	4	2	7	LPr	soP (m.E./o.E.)	H	English	0%		1	7
	CS1	Control Systems 1		4		SU	sP	90-180 min		100%			
21	ESF	Embedded Systems and Fieldbuses	4	4	5	SU, Ü, LPr	sP	90-120 min	English	yes		1	5
22	STCS2	System Theory and Control Systems 2	4 / 5	2 / 2	5	SU	sP	90-120 min	English	yes		1	5
	DSMS	Design and Simulation of Mechatronic Systems								yes			
23	SLab	Simulation Lab	5	1	7	LPr	soP (m.E./o.E.)	H	English	0%		1	7
	DSS	Design and Simulation of Mechatronic Systems		4		SU, Ü	sP	90-180 min		100%			
24	CE1	Core Elective 1	5	8	10	SU, Ü, LPr	sP	90-180 min	English	yes		1	10
25	CE2	Core Elective 2	5	8	10	SU, Ü, LPr	sP	90-180 min	English	yes		1	10
26	PRC	Practice-Related Courses	6	6	6	SU, Ü, S	sP (m.E./o.E.)	90-120 min	German/ English[2]	no	Tpf	0	0
27	INT	Internship	6	0	24	Pr	m.E./o.E.	[3]	German/ English[2]	no	90 CP	0	0
28	GELab	General Engineering Lab	7	5	6	LPr	soP	H	English	yes		1	6
29	EP	Engineering Project	7	4	7	SU, Ü, LPr	soP	A	German/ English[2]	yes	90 CP	1	7
30	BT	Bachelor's Thesis	7	0	12	--	BA	--	German/ English[2]	yes	INT + CS + 150 CP	1	12
31	BS	Bachelor's Seminar	7	3	5	S	soP (m.E./o.E.)	C	German/ English[2]	no	Tpf	0	0
		Total		140	210								144,5

Abbreviations:

BA	Bachelor's thesis
bZv	*besondere Zulassungsvoraussetzungen* = admittance depends on particular condition
CE	Core Elective
CP	Credit Point(s)
GE	General Elective
LPr	*Laborpraktikum/-übung* = lab course
mP	*mündliche Prüfung* = oral examination
m.E./o.E.	*mit Erfolg/ ohne Erfolg* = passed successfully/failed
Pr	*Praktikum* = internship
Pro	*Projekt* = project
S	Seminar
soP	*sonstige Prüfung* = other examined assignment - the type of the other examined assignment is laid down in the curriculum and announced at the start of the semester by the responsible lecturers. Students have to take just one of the examinations mentioned in column 9.
sP	*schrifliche Prüfung* = written examination
SU	seminaristischer Unterricht = seminar-like lecture
SWS	*Semesterwochenstunden* = credit hours
Tpf	*Teilnahmepflicht* = compulsory attendance - If non-attendance at scheduled dates is higher than 25%, admittance to examinations is refused. In this regard it does not matter whether non-attendance was due to reasons the student is responsible for or not. Attendance is to be recorded on attendance lists by signing. The person responsible for the module is also responsible for the attendance lists.
Ü	*Übung* = exercise course
V	*Vorlesung* = lecture
[1]	Details are laid down by the Faculty of Applied Natural Sciences and Humanities.
[2]	as preferred by student
[3]	see § 8 (8) of these study and examination regulations

Other examined assignments (soP) include:
A= project; B= presentation; C= multimedia presentation; D= documentation report; E= colloquium; F= written assignment; G= portfolio assignment;
H= practical assignment

The English text in this document only serves the purpose of providing information on the contents of the corresponding German text. Only the German text is legally binding.

1.2 Alternative Study Plans

The study and examination regulations (SPO) of the undergraduate degree programme Mechatronics are designed in such a way that a high degree of flexibility is achieved and thus different variants of the course of studies are possible. Thus, it is possible to meet the expectations and wishes of the students as well as the requirements of the industry, e.g. with regard to the Bachelor's Thesis and the Internship.

Some variants are shown in the following map. Further information on the variants as well as their advantages and disadvantages will be discussed at the internship-related information event. This topic can also be discussed with the programme advisor.

Study Plan.

Semester	1		2		3		4		5		6		7		Remarks
Phase	Foundation Phase						Core Phase				Application and Industrial Phase				
Variant A	FM		FM		FM		CM		CM/E		INT		EP	BT	The declaration of the final grade may shift to the 8th Semester!
Variant B	FM		FM		FM		CM		CM/E		INT	BT	EP		The continuity between the Internship and the Bachelor's Thesis allows an extensive investigation of complex problems.
Variant C	FM		FM		FM		CM		CM/E		EP	INT	BT		The continuity between the Internship and the Bachelor's Thesis allows an extensive investigation of complex problems.
Individual Plan															

FM	Foundation Modules
(no label)	Semester Break
CM	Modules of the core phase
CM/E	Modules of the core phase with Core Electives
INT	Internship
EP	Engineering Project
BT	Bachelor's Thesis

1.3 Matrix of Learning Objectives

The matrix below provides an overview of the primary learning objectives achieved with the modules (module numbers in brackets). The concrete learning objectives and contents of the individual modules are described in the module descriptions in the following sections.

Specialist knowledge and understanding of the engineering discipline	Comprehensive engineering, mathematical and scientific knowledge of electrical engineering, mechanical engineering and information processing, enabling scientifically well-founded work and the ability to take responsibility for professional activities Understanding of the multidisciplinary context of engineering	Actuators (18) Electrical Engineering 1 and 2 (8, 13) Embedded Systems and Fieldbuses (21) Design and Simulation of Mechatronic Systems (23) Fundamentals of Electrical Engineering (4) Fundamentals of Mechanical Design with 3D-CAD (5) Computing 1 and 2 (1, 6) Engineering Mathematics 1 and 2 (2, 7) Elements of Mechanical Design and Strength of Materials (14) Measuring Techniques (17) Microcomputer Systems (11) Numerical Mathematics (12) Physics (3) Control Systems 1 (20) Logical Control and Software Engineering (19) System Theory and Control Systems 2 (22) Engineering Mechanics 1 and 2 (9, 15) Core Electives 1 and 2 (24, 25)
Independent application of scientific knowledge and methods	Ability to identify, define and solve mechatronics problems using established scientific methods Ability to carry out scientifically well-founded analysis of products, processes and methods within their discipline Ability to select appropriate analysis, modelling, simulation and optimisation methods and apply them with a high degree of competence	Actuators (18) General Engineering Lab (28) Bachelor's Thesis Electrical Engineering 1 and 2 (8, 13) Embedded Systems and Fieldbuses (21) Design and Simulation of Mechatronic Systems (23) Fundamentals of Electrical Engineering (4) Fundamentals of Mechanical Design with 3D-CAD (5) Computing 1 and 2 (1, 6) Engineering Mathematics 1 and 2 (2, 7) Elements of Mechanical Design and Strength of Materials (14) Measuring Techniques (17) Microcomputer Systems (11) Numerical Mathematics (12) Physics (3) Internship (27) Engineering Project (29) Control Systems 1 (20) Logical Control and Software Engineering (19) System Theory and Control Systems 2 (22) Engineering Mechanics 1 and 2 (9, 15) Core Electives 1 and 2 (24, 25)

Engineering development and design	Students acquire the ability to develop designs for machines, devices, IT programmes or processes in accordance with their level of knowledge and understanding, and in accordance with specific requirements. Students have a practical understanding of design methods and the ability to apply these methods competently.	General Engineering Lab (28) Bachelor's Thesis Electrical Engineering 1 and 2 (8, 13) Design and Simulation of Mechatronic Systems (23) Fundamentals of Mechanical Design with 3D-CAD (5) Computing 1 and 2 (1, 6) Elements of Mechanical Design and Strength of Materials (14) Microcomputer Systems (11) Internship (27) Engineering Project (29) Control Systems 1 (20) Logical Control and Software Engineering (19) System Theory and Control Systems 2 (22) Engineering Mechanics 1 and 2 (9, 15) Core Electives 1 and 2 (24, 25)
Research and assessment	Students are able to conduct literature research in accordance with their level of knowledge and understanding, and use databases as well as other sources of information in their work. Students can plan and carry out appropriate experiments in accordance with their level of knowledge and understanding, interpret this data, and draw relevant conclusions from it.	General Engineering Lab (28) Bachelor's Thesis Practice-Related Courses (26) Internship (27) Engineering Project (29) Core Electives 1 and 2 (24, 25)
Engineering practice	Students are able to transfer engineering and scientific results to industrial and commercial production, taking into account business, ecological and safety requirements. Students can plan, manage and monitor processes and develop and operate plant and equipment. Students are able to build independently on what they have learned.	General Engineering Lab (28) General Elective Modules (16) Bachelor's Thesis Bachelor's Seminar (31) Foreign Language (10) Practice-Related Courses (26) Internship (27) Engineering Project (29) Core Electives 1 and 2 (24, 25)

Social skills	Students are able to communicate regarding content and problems concerning the subject area with both their colleagues and with a wider public, including in a foreign language and across different cultures. Awareness of social and ethical responsibility and knowledge of professional ethical principles and standards. Students can work both independently and as a member of international, mixed-gender groups to effectively organise projects and accept leadership responsibility. They have sufficient practical experience to work in a business or scientific environment. Capacity for life-long learning.	General Engineering Lab (28) General Elective Modules (16) Bachelor’s Thesis Bachelor's Seminar (31) Foreign Language (10) Practice-Related Courses (26) Internship (27) Engineering Project (29) Core Electives 1 and 2 (24, 25)

2 First Part of Studies, 1st to 3rd Semester

Subject Area: Computer Science

Responsible for subject area: Prof. Dr.-Ing. Ochs

Module 1

Computing 1

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr. Norbert Strobel

Lecturer(s):

Prof. Dr. Norbert Strobel

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, computer lab exercises.	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 1st semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language
Assignment according to §15a of the study and examination regulations (format: practical assignment)		English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

On completion of the course, students understand the fundamental concepts of computing. They understand the significance of the computer architecture for basic programming paradigms. They will have learnt the C/C++ programming language, understood how to represent and organize data, and be able to use elementary language constructs and control structures. Thanks to their knowledge of data structures and computer programming concepts, students will be able to code independently as well as understand and thoroughly analyse proposed software solutions to engineering problems.

Contents
• Basic concepts of computing • Computer architecture • Fundamentals of programming • Digital representation of data • Elementary language constructs such as variables, data types, operators, statements • Implementation of control structures • Organization of data and program design • Arrays, data types, functions, classes
Literature
• C. Horstmann, C++ for Everyone, Wiley, 2011. • P. Deitel, C++ How to Program (Early Objects Version), Pearson, 2017. • W. Savitch, Problem Solving with C++, Pearson, 2015. • P. Deitel, C: How to Program, Pearson, 2009. • H. Herold, B. Lurz, J. Wohlrab, Grundlagen der Informatik, Pearson, 2007 (in German). • Notes to lectures in the FHWS eLearning system
Special notes

Module 6

Computing 2

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 180 hrs 75 hrs attendance time (5 SWS) 75 hrs self-directed study time 30 hrs time for exam preparation	6

Responsible for module: Prof. Dr. Norbert Strobel

Lecturer(s):

Prof. Dr. Norbert Strobel

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, computer lab exercises.	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 2nd semester)

Conditions of participation in accordance with study and examination regulations

Content of module 1 (Computing 1)

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

On completion of the course, students will have acquired an advanced understanding of algorithms and data structures. In particular, they will be familiar with the properties and use cases of data structures as well as abstract data types, and will have learnt about algorithms. This will enable them to select suitable data representations and develop appropriate software solutions for given problems. With their advanced knowledge of arrays, structures, and classes, they will be able to solve complex software engineering problems, for example, using recursive or iterative programming approaches. In addition, they will have acquired the skills to do a problem-oriented software design independent of any particular programming language. This will enable them to develop sophisticated software solutions in C/C++ and other programming languages as well.

Contents

- Arrays, pointers, and vectors
- Structures and classes
- Iterative and recursive programming
- Dynamic memory management
- Important data structures and algorithms
    - Linear and linked lists, trees, hash tables, stacks and queues
    - Search, sort
- Implementation of data structures and algorithms

Literature
• C. Horstmann, C++ for Everyone, Wiley, 2011. • P. Deitel, C++ How to Program (Early Objects Version), Pearson, 2017. • W. Savitch, Problem Solving with C++, Pearson, 2015. • P. Deitel, C: How to Program, Pearson, 2009. • H. Herold, B. Lurz, J. Wohlrab, Grundlagen der Informatik, Pearson, 2007 (in German). • Notes to lectures in the FHWS eLearning system
Special notes

Module 11

Microcomputer Systems

Module length	Frequency	Workload	ECTS Credit Points
2 semesters	annual	Total: 240 hrs 105 h attendance time (7 SWS) 95 hrs self-directed study time 40 hrs time for exam preparation	8

Responsible for module: Prof. Dr. rer. nat. Bettina Brandenstein-Köth

Lecturer(s):

Prof. Dr. rer. nat. Markus Mathes

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, Exercise courses, Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 2nd and 3rd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language
Written exam	120 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

On completion of the course, students will have learned and understand the basic elements of digital circuits. They will be able to apply various number system, in particular binary and hexadecimal representation, and will understand the need for different representation codes. Students are able to synthesise and optimise digital circuits and finite-state machines. They are able to develop and analyse time-dependent digital circuits. They also understand the structure and classification of a digital computer and can explain the interplay between CPU, memory, peripheral and bus system, as well as how modern computer architecture works. This enables them to programme microcontrollers taking a selected example.

Contents

- Binary and hexadecimal number representation
- Addition, subtraction and multiplication in the dual system
- Advantages and disadvantages of different representation codes
- Calculation rules of boolean algebra
- Digital circuit design and key basic circuits
- Classification of bi-stable flip-flops
- Overview of different processors and microcontroller architectures
- Fundamental elements of a microcomputer and microcontroller
- Overview of modern research architectures

Literature
• Thomas L. Floyd, Digital Fundamentals, Pearson, 2015 • Ronald J. Tocci, Frank J. Ambrosio, Microprocessors and Microcomputers, Pearson, 2002 • H. Bähring, Mikrorechnertechnik I+II, Springer, 2005 • T. Beierlein, O. Hagenbruch, Taschenbuch der Mikroprozessortechnik, Hanser, 2011 • B. Schaaf, Mikrocomputertechnik, Hanser, 2012 • K. Beuth, Digitaltechnik, Vogel Buisness Media, 2006 • R. Woitowitz, K. Urbanski, W. Gehrke, Digitaltechnik, Springer, 2012 • K. Fricke, Digitaltechnik, Vieweg+Teubner Verlag, 2014
Special notes

Subject Area: Mathematics

Responsible for subject area: Prof. Dr. rer. nat. H.-J. Meier

Module 2

Engineering Mathematics 1

Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 210 hrs 90 hrs attendance time (6 SWS) 90 hrs self-directed study time 30 hrs time for exam preparation	7

Responsible for module: Prof. Dr. rer. nat. H.-J. Meier

Lecturer(s):

Prof. Dr. Bier, Prof. Dr. Diethelm, Prof. Dr. Mark, Prof. Dr. Motzek, Prof. Dr. H. Walter, Prof. Dr. G. Wimmer, Prof. Dr. Zirkelbach

Associated class(es)	**Teaching and learning format**	**Language of instruction**
	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 1st semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Contents of mathematics for secondary schools (or similar)

Examination type	**Examination length**	**Examination language**
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

The course teaches the fundamentals of the analysis of functions of variable and linear algebra. Students learn the mathematical backgrounds (concepts, theories and processes), and develop technical mathematical skills.

They become equipped to grapple with mathematical literature, and so develop more advanced mathematical educational content. The course enables students to process and understand the mathematically-oriented content of specialist courses. They thus have the mathematical tools required to solve elementary mechatronics problems.

Contents

- Vector calculation in space
- Matrices
- Complex numbers
- Partial fraction analysis
- Functions
- Limit values
- Differential calculation of a variable

Literature

- K.A. Stroud and Dexter J. Booth: Engineering Mathematics - Palgrave Macmillan (Publisher) 7th edition, 2013.
- James Stewart: Calculus - Cengage Learning (Publisher), 7th edition, 2012.
- Notes to lectures in the FHWS eLearning system

Special notes

Module 7

Engineering Mathematics 2

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 210 hrs 90 hrs attendance time (6 SWS) 90 hrs self-directed study time 30 hrs time for exam preparation	7

Responsible for module: Prof. Dr. rer. nat. H.-J. Meier

Lecturer(s):

Prof. Dr. Bier, Prof. Dr. Diethelm, Prof. Dr. Mark, Prof. Dr. Motzek, Prof. Dr. H. Walter, Prof. Dr. G. Wimmer, Prof. Dr. Zirkelbach

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 2nd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Content of module 2 (Engineering Mathematics 1)

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

The lecture teaches the fundamentals of the analysis of functions of one and multiple variables. Students learn the mathematical backgrounds (concepts, theories and processes), and develop technical mathematical skills. They become equipped to grapple with mathematical literature, and so develop more advanced mathematical educational content. The lecture enables students to process and understand the mathematically-oriented content of specialist courses. They thus have the mathematical tools required to solve elementary mechatronics problems.

Contents

- Integral calculus
- Functions of multiple variables
- Differential equations
- Fourier series
- Multiple integrals
- Laplace transform

Literature
• K.A. Stroud and Dexter J. Booth: Engineering Mathematics - Palgrave Macmillan (Publisher) 7th edition, 2013. • James Stewart: Calculus - Cengage Learning (Publisher), 7th edition, 2012. • Notes to lectures in the FHWS eLearning system
Special notes

Module 12

Numerical Mathematics

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 180 hrs 60 hrs attendance time (4 SWS) 80 hrs self-directed study time 40 hrs time for exam preparation	6

Responsible for module: Prof. Dr. H. Walter

Lecturer(s):

Prof. Dr. H. Walter, Prof. Dr. G. Wimmer

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, Exercise course, Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 3rd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Content of modules 2 (Engineering Mathematics 1) and 7 (Engineering Mathematics 2)

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

On completion of this course, the students know the fundamental processes and approaches of numerical analysis. The students will be able to apply numerical methods and to select appropriate numerical algorithms to solve standard mathematical problems.

They will also be able to write computer programs using the software package MATLAB. They can implement the selected algorithms within MATLAB and determine valid solutions for specific mathematical problems.

Contents

- Error calculation
- Interpolation
- Numerical differentiation
- Numerical integration
- Iteration
- Differential equations

Literature
• J. Stoer, R. Bulirsch: Introduction to Numerical Analysis (Texts in Applied Mathematics), Springer, 3rd Edition, 2010 • R.L. Burden, J.D. Faires: Numerical Analysis, Brooks Cole, 9th Edition, 2010 • F. B. Hildebrand: Introduction to Numerical Analysis, Dover Publications, 2nd Edition, 1987 • Jeffery J. Leader: Numerical Analysis and Scientific Computation, Pearson, 1st Edition, 2005 • Erwin Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons, 10th Edition, 2011 • Lecture notes in the FHWS eLearning system
Special notes

Subject Area: Electrical Engineering

Responsible for subject area: Prof. Dr. Heinz Endres

Module 4

Fundamentals of Electrical Engineering

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 240 hrs 90 hrs attendance time (6 SWS) 110 hrs self-directed study time 40 hrs time for exam preparation	8

Responsible for module: Prof. Dr. Norbert Strobel, Prof. Dr. Heinz Endres

Lecturer(s):

Prof. Dr. Jan Hansmann

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, computer lab exercises.	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 1st semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students will have gotten to know the basics of electrical engineering. They will have become familiar with different methods to analyse linear networks (electrical circuits), and be able to apply complex numbers to find the voltages across, and the currents through, components in the network. They will have understood the behaviour of passive components, and so be able to determine the frequency behaviour of simple, analogue filters.

Contents

- Fundamental concepts of electrical engineering
  (electrical circuits, Ohm's law, equivalent circuits, energy and power)
- Basic circuit theorems (Kirchhoff's circuit laws, network conversions)
- Systematic analysis of linear networks
- Fundamental concepts of alternating current, representation as complex pointers
- Frequency behaviour of electronic circuits, analogue filters
- Fundamentals of three-phase systems

Literature
• T. L. Floyd, Principles of Electric Circuits, Pearson, 2016. • J. Nilsson and S. Riedel, Electric Circuits, Pearson, 2014. • C. Alexander and M. Sadiku, Fundamentals of Electric Circuits, McGraw-Hill Education, 2012. • John O'Malley, Schaum's Outline of Basic Circuit Analysis, McGraw-Hill Education, 2011. • Mahmood Nahvi, Schaum's Outline of Electric Circuits, McGraw-Hill Education, 2013. • Notes to lectures in the FHWS eLearning system
Special notes

Module 8

Electrical Engineering 1

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 180 hrs 90 hrs attendance time (6 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	6

Responsible for module: Prof. Ulrich Mann

Lecturer(s):

Prof. Dr. Jan Hansmann

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 2nd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Fundamentals of Electrical Engineering

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students understand the theoretical principles of electric and magnetic fields and are familiar with electromagnetic field forces. They are familiar with the most important components of electronics, and can calculate their behaviour in basic electronic circuits. They understand the principles of electronic circuit design and are familiar with various circuit technologies.

Contents

- Electric and magnetic fields
- Induction
- Passive components
- Active components
- Semiconductor components
- Circuit engineering

Literature
• Hering, Martin, Storer: Physik für Ingenieure, Berlin-Heidelberg, Springer Verlag, 2012 • Wilfried Weissgerber, Elektrotechnik für Ingenieure 1: Gleichstromtechnik und Elektromagnetisches Feld, 8. Auflage, Vieweg & Teubner, 2008. • Wilfried Weissgerber: Elektrotechnik für Ingenieure 2: 8. Auflage, Vieweg & Teubner, 2008. • Siegfried Altmann, Detlef Schlayer: Lehr- und Übungsbuch Elektrotechnik, 4. Auflage, Hanser Verlag München, 2008. • Hering, Martin, Storer: Physik für Ingenieure, Berlin-Heidelberg, Springer Verlag, 2012 • U. Tietze, Ch. Schenk: Halbleiter-Schaltungstechnik, 12. Auflage, Berlin-Heidelberg-New York, Springer Verlag, 2002 • Notes to lectures in the FHWS eLearning system
Special notes

Module 13

Electrical Engineering 2

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Ali

Lecturer(s):

Prof. Dr. Kaupp

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 3rd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Module 4 (Fundamentals of Electrical Engineering) and Module 8 (Electrical Engineering 1)

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are able to understand, analyse and synthesise basic four-pole networks. They understand the behaviour of linear, dynamic systems and are able to derive its mathematical description and solution. Students understand the significance and application of transfer functions.
Participants are able to interpret and analyse these basic methods and to structure them in terms of a given problem.
Students of this module can apply these methods to given problems, and are able to transfer this knowledge to other technical problems.

Contents

- Four-pole equations, elementary four-pole networks, synthesis of four-pole networks and operating parameters
- Derivation of differential equations for systems with one or two energy storing components, solution in the time and frequency domain, significance and determination of initial conditions
- Symbolic methods of determining the transfer function, the step response, stability and frequency response

Literature

- Notes to lectures with exercises in the eLearning system
- Van Valkenburg, M. E. Network Analysis, PHI / Pearson Education, 3rd Edition. Reprint 2002
- Various text books, e.g. Weissgerber, Wilfried; Elektrotechnik für Ingenieure 3, Vieweg-Verlag

Special notes

Subject Area: Mechanical Engineering

Responsible for subject area: Prof. Dr.-Ing. Schlachter

Module 5

Fundamentals of Mechanical Design with 3D-CAD

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. T. Müller

Lecturer(s):

Prof. Dr.-Ing. T. Müller, Prof. Dr.-Ing. A. Hofmann, Prof. Dr.-Ing. Ch. Bunsen

Associated class(es)	Teaching and learning format	Language of instruction
3D-CAD Lab (CADLab; 1 SWS)	Lab course	English
Fundamentals of Mechanical Design (MD; 3 SWS)	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 1st semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language
(CADLab) Other examination	Practical examination	English
(MD) Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Following their active participation in this course, students understand the importance and application of basic technical standards. They are able to produce technical drawings of simple objects that comply with standards, either free-hand or using a 3D CAD system. After modelling simple components, they are able to create basic assembly groups.

Students are able to specify the basic structure of metal and non-metal materials and assess their areas of application within the limits of key manufacturing processes. They are also able to assess the impacts of these manufacturing processes on tolerances and technical surfaces.

Finally, students are familiar with the sequence and the interfaces of the process steps of systematic product development in accordance with the VDI guideline 2221.

Contents
• Standardisation process and technical standards • Fundamentals of depicting machine parts / reading of technical drawings • Construction materials and manufacturing processes • The life cycle of a product: Planning - Conception - Design - Development • Simple construction details (tolerances, fits, technical surfaces) • Introduction to a 3D CAD system - application of basic drawing and design knowledge to the modelling of machine components and assembly groups
Literature
• Grote et. al.: Springer Handbook of Mechanical Engineering; Springer Handbooks, (January 13th 2009) • Dillinger et. al.: Metal Engineering Textbook, Europa-Nr.: 12432, (1st edition 2016) • Dubbel: Taschenbuch für den Maschinenbau (German), Springer Vieweg; Auflage: 24 (September 9th 2014) • Hoischen: Technisches Zeichnen: Grundlagen, Normen, Beispiele, Darstellende Geometrie (German), Cornelsen Verlag; Auflage: 35, revised and updated edition. (February 1st 2016) • H.-J. Bargel, G. Schulze: Werkstoffkunde (German), Springer Vieweg; Auflage: 12 (May 11th 2016) • Callister: Materials Science and Engineering - An Introduction, John Wiley, (7th edition 2007) • Pahl, Beitz; Engineering Design – A Systematic Approach, Springer, (3rd edition 2007) • Notes to lectures in the FHWS eLearning system
Special notes

Module 14

Elements of Mechanical Design and Strength of Materials

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Spielfeld

Lecturer(s):

Prof. Dr.-Ing. Bunsen, Prof. Dr.-Ing. Felsner

Associated class(es)	Teaching and learning format	Language of instruction
Elements of Mechanical Design and Strength of Materials	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 3rd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Module 9 (Engineering Mechanics 1)

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are able to compute internal forces and -moments applying the principle of intersection. Students are able to calculate the shear and -normal stresses for a 2 dimensional case in a sheet for different angles of intersection. They are able to calculate the primary normal and primary shear stresses for different load cases (normal/lateral -force, torsion and bending). They can calculate effective stresses by different hypotheses. Students are able to calculate deformations arising from various load cases.
With the knowledge acquired, students are able to perform a strength assessment. This includes an assessment for fatigue of components. Students are familiar with common roller bearing types. They are able to select bearings for a specific application, perform a bearing calculation, and design screw connections.

Contents

- Types of stress: Tensile/normal compressive stresses. Normal bending stresses. Torsion shear stresses
- Two-dimensional stress state
- Deformation by torsion
- Deflection curves
- Equivalent stress hypotheses
- Material parameters
- Dynamic loads and strength assessment
- Roller bearing technology and bearing design
- Design of screw connections

Literature
• Documents from the eLearning system • Heinzelmann, M; Lippodt, A.-L.: Technische Mechanik in Beispielen und Bildern. Spektrum (2008). • Mayr, M.: Technische Mechanik, Hanser Verlag, 7. Auflage, 2012.
Special notes
• Tutorials

Module 9

Engineering Mechanics 1 (Statics)

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Christel

Lecturer(s):

Prof. Dr.-Ing. Felsner, Prof. Dr.-Ing. J. Meyer

Associated class(es)	Teaching and learning format	Language of instruction
Engineering Mechanics 1 (Statics)	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 2nd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

linear algebra, trigonometry

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

On completion of the course, students understand the working methods and techniques used to reduce forces and torque. They are familiar with the method of sections and have an understanding of Coulomb friction. They thus have the professional competence to deal with forces and torque on rigid bodies and are able to apply these to calculate loads and stress resultants for technical components. They are able to critically question the results and assess influences on the results. Students are able to apply this knowledge to examples of practical use.

Contents

- Force addition and equilibrium of forces in central and general force systems
- Characteristic features of selected joints, bearings
- Center of gravity calculation
- Method of sections, Newton's laws
- Calculation of bearing reactions and stress resultants
- Spatial force systems and rigid body systems
- Static friction, dynamic friction, rope friction

Literature
• Gross, Hauger, Schröder, Wall, Rajapakse: Engineering Mechanics 1 – Statics, Springer Verlag, Edition 2, 2013 • Mayr, M.: Technische Mechanik, Hanser Verlag, 7. Auflage, 2012 • Holzmann, Meyer, Schumpich: Technische Mechanik Statik, Springer Verlag, 2015 • Gabbert und Raecke: Technische Mechanik, Hanser Verlag, 7. Auflage, 2013 • Notes to lectures in the FHWS eLearning system
Special notes

Module 15

Engineering Mechanics 2 (Dynamics)

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Schlachter

Lecturer(s):

Prof. Dr.-Ing. Christel, Prof. Dr.-Ing. Retka

Associated class(es)	Teaching and learning format	Language of instruction
Engineering Mechanics 2 (Dynamics)	Seminar-like lectures, Exercise course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 3rd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Successful completion of modules 2, 7 and 3, and in particular module 9

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Following active completion of the course, students understand the key principles of kinematics and kinetics of rigid bodies in the plane. Working on partially abstract assignments, they are able to solve realistic mechanical problems. Students are familiar with, and are able to apply, at least one method to form equations of motion. They also understand the mass properties of rigid bodies, and are able to manage (3D CAD) and interpret these. Students are able to analyse the kinematics of simple mechanical linkages and assess their kinetics. They understand the fundamentals of mechanical vibrations and are able to apply conservation laws.

Contents

- Point kinematics
- Kinematics of the rigid body in the plane
- Fundamentals of kinetics, work and energy, performance and efficiency
- Point kinetics, equations of motion
- Mass parameters
- Kinetics of the rigid body in the plane, linear and angular momentum

Literature

- Gross, Hauger, Schröder, Wall, Govindjee: Engineering Mechanics 3 – Dynamics, Edition 2, Springer Verlag, 2014
- R. C. Hibbeler: Engineering Mechanics - Dynamics, Edition 14; Pearson Studium, 2016
- Notes to lectures in the FHWS eLearning system

Special notes

Module 3

Physics

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr. Mark

Lecturer(s):

Prof. Dr. Mark, Prof. Dr. Motzek, Hr. Fabeck, Prof. Dr. J. Seufert, Prof. Dr. H. Walter

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, Exercise course, Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regula-

Mechatronics Bachelor's degree programme (core module, 1st semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

On completion of the course, students are familiar with the basic physical concepts required to understand the subject areas of 'vibrations and waves' and 'thermodynamics'. Based on the fundamental physical equations governing these fields, they are able to work with the relevant physical quantities and to perform calculations. They understand the significance of the concepts explained in technical applications and are able to apply these to new examples. They are also able to uncover and explain these concepts in selected sample applications. Students are also familiar with the basic concepts of quantum mechanics.

Contents

- Harmonic oscillations
- Superposition of oscillations: Beats
- Wave functions (plane waves, circular/cylindrical waves, spherical waves)
- Huygens-Fresnel principle: Reflection, refraction, diffraction
- Standing waves
- Classical and relativistic Doppler effect
- Sound levels: Quantification of loudness
- Electromagnetic waves and polarisation effects
- Quantisation of energy transport by electromagnetic waves: Photons
- Wave nature of particles
- Bohr model of the atom
- Heat as energy on the microscopic level: First law of thermodynamics, heat capacity
- Equation of state and special processes of the ideal gas
- Thermodynamic cycles, Carnot efficiency
- Fundamentals of fluid mechanics (hydrostatic pressure, dynamic pressure)

Literature

- Paul A. Tipler, “Physics for scientists and engineers”
- Notes to lectures in the FHWS eLearning system

Special notes

Module 10

Foreign Language

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Every summer semester	Total: 60 hrs 30 hrs attendance time (2 SWS) 30 hrs self-learning assignment (in total)	2

Responsible for module: Prof. Dr. Wunderlich

Lecturer(s):

Prof. Dr. Wunderlich

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar	German / English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 2nd semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

English: Completion of Level B2 according to the Common European Framework of Reference for Languages

German: Completion of Level A2 according to the Common European Framework of Reference for Languages

Examination type	Examination length	Examination language
Written exam	90 min	Dependent on the language chosen, English or German

Credit Points will be awarded only on successful completion of the examination!

Learning objective

English for Mechatronics: This course will will lead students to the level C1 and help students improve their knowledge of technical and business English, consolidate their grammatical expertise as well as hone their communication skills in professional situations. Students will practice using English successfully in specific professional situations, e.g. taking part in technical discussions and negotiations, preparing technical descriptions, giving presentations, incl. descriptions of graphs, tables, etc. They will work on enhancing their reading comprehension skills by perusing authentic texts, while their listening comprehension skills will benefit from audio material taken from professional life. **Students will hone their business- and technology-related as well as their academic writing skills, e.g. by composing business letters and technical reports**.

German for Mechatronics: This course will lead students to the level B1 and help them practice the four essential skills as well as audio and video comprehension skills. It will also give them a solid grounding in vocabulary and grammar. It will cover interesting subjects as well as impart general knowledge and useful tips on how to live, work and study abroad.

Contents
•
Literature
• Teaching material will be provided.
Special notes

Module 16

General Elective Module

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Every semester	Total: 150 hrs 60 hrs attendance time (1 course á 4 SWS, or 2 courses á 2 SWS) 75 hrs self-learning assignment (in total) 15 hrs preparation for examinations	5

Responsible for module: Frau Maria Weikl

Lecturer(s):

Respective lecturer for general elective module chosen

Associated class(es)	Teaching and learning format	Language of instruction
2 modules / 1 module as selected by the student from the course catalogue for general elective modules	Seminar; tutorial	Dependent on the module chosen; see respective specifications

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 3rd semester);
General electives are open to students of all faculties

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Subject to the module chosen; see respective specifications as stipulated by Faculty of Applied Natural Sciences in the course catalogue

Examination type	Examination length	Examination language
Dependent on the module chosen; see respective specifications;	usually written exam of 90 min, sometimes presentation or other form of exam	Dependent on the module chosen; see respective specifications

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

The respective learning objectives are subject to the module chosen. Please view the relevant description in the course catalogue of the Faculty of Applied Natural Sciences and Humanities online.
On completion of their general elective modules, students will be able to apply the knowledge acquired in their course of studies within an interdisciplinary context. Moreover, they will have developed a sense of their personal and social responsibility. They will have honed their key skills and / or become more proficient in a foreign language. The general elective courses´ objective is to broaden a student´s horizon, to further their personal development and to help develop their awareness for intercultural differences.

Contents

- Impartment of general knowledge
- Honing key skills like presentation and communication skills
- Foreign languages
- The modules offered as well as the course descriptions can be found in the respective catalogues for general elective modules:
    - For Schweinfurt: http://fang.fhws.de/studium/allgemeinwissenschaftliche_wahlpflichtfaecher/angebote_in_schweinfurt/aktuelles_und_termine.html
    - For Würzburg: http://fang.fhws.de/studium/allgemeinwissenschaftliche_wahlpflichtfaecher/angebote_in_wuerzburg/aktuelles_und_termine.html

Literature

- In accordance with description in the course catalogue; lecture notes may be available on the university´s e-learning site

Special notes

- Specific online courses by the Virtual University of Bavaria are also available.
- Some courses include excursions and guest lectures.

3 Second Part of Studies, 4th, 5th and 7th Semester

Subject Area: Sensors, Measuring Techniques and Actuators

Responsible for subject area: Prof. Dr.-Ing. Wilke

Module 17

Measuring Techniques

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs independent study 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Wilke

Lecturer(s):

Prof. Dr.-Ing. Hansmann, Prof. Dr.-Ing. Kharitonov

Associated class(es)	Teaching and learning format	Language of instruction
Measuring Techniques	Seminar-like lectures, Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module , 4th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Passes in the subject areas of mathematics, physics, electrical engineering and mechanical engineering

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are familiar with the fundamentals of measuring techniques and are able to explain them as well as use them in technical systems. They can also analyse technical systems and develop mathematical description models for abstraction so that they can solve technical measuring tasks independent of the technical system characteristics. To this end, they are able to schedule targeted work tasks and implement them in practice. They are able to argue their proposed solutions clearly.

Contents

- Fundamentals of metrology, measuring inaccuracies, error calculation
- Measuring system technology, measurement data processing
- Fundamentals of sensors
- Current and voltage measurement
- Measuring bridges
- Operational amplifiers

Literature
• Bentley, John: Principles of Measurement Systems 4th Edition; Pearson Education, Harlow, 2004 • Beckwit, T.; Marangoni R.; Lienhard, J. V.: Mechanical Measurements, Pearson Education, Harlow, 2006 • Witte, Robert: Electronic Test Instruments, 2nd Edition, Pearson Education, Harlow, 2002 • DIN 1319-1:1995-01 Fundamentals of metrology - Part 1: Basic terminology • DIN 1319-2:2005-10 Fundamentals of metrology - Part 2: Terminology related to measuring equipment • DIN 1319-3:1996-05 Fundamentals of metrology - Part 3: Evaluation of measurements of a single measurand, measurement uncertainty • DIN 1319-4:1999-02 Grundlagen der Messtechnik, Teil 4: Auswertung von Messungen; Meßunsicherheit • JCGM 100:2008: Guide to the Expression of Uncertainty in Measurement (GUM) • Notes to lectures in the FHWS eLearning system
Special notes

Module 18

Actuators

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs independent study 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Latour

Lecturer(s):

Prof. Dr.-Ing. Latour, Prof. Dr.-Ing. B. Müller, Prof. Dr.-Ing. Versch

Associated class(es)	Teaching and learning format	Language of instruction
Actuators	Seminar-like lectures, Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module , 4th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Passes in the subject areas of mathematics, physics, electrical engineering and mechanical engineering

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are familiar with the physical operating principles, as well as the structure and function of electrical and fluid-based drive solutions. They are able to derive the mathematical correlations of the causal loops for selected drive systems and to design these according to technical requirements. As such, they can analyse the technical requirements and plan the drive system based on the components. Students are able to schedule targeted work tasks and implement them in practice. They can critically evaluate the desired results.

Contents

Electrical actuators:

- Configuration and function of direct current, synchronous and asynchronous motors
- Fundamentals of associated power electronics (direct current, alternating current and inverters)
- Configuration, function and control of stepper motors and electrical linear and Piezo drives

Fluid-based actuators:

- Fundamentals of fluid-based drive and control technology
- Configuration and function of hydrostatic machines (pumps and motors) as well as standard valve types (pressure, flow, way and check valves)
- Design and description of selected hydrostatic drive solutions
- Application examples from plant automation and mobile hydraulics

Literature
Electrical actuators: • Hughes: Electric Motors and Drives: Fundamentals, Types and Applications, Newens, 4th ed., 2013 • Mohan et al.: Power Electronics, John Wiley & Sons, 3rd. ed., 2002 Fluid-based actuators: • Murrenhoff: Fundamentals of Fluid Power – Hydraulics, Shaker, 8th Edition 2016 • Notes to lectures in the FHWS eLearning system
Special notes

Module 19

Logical Control and Software Engineering

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 180 hrs 75 hrs attendance time (5 SWS) 75 hrs self-directed study time 30 hrs time for exam preparation	6

Responsible for module: Prof. Dr.-Ing. M. Ochs

Lecturer(s):

Prof. Dr. Kaupp, Prof. Dr. rer. nat. Mathes

Associated class(es)	Teaching and learning format	Language of instruction
Logical Control and Software Engineering	Seminar-like lectures	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics bachelor's degree programme (core module, 5th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Foundation modules in Computer Science (1, 6, 11)

Examination type	Examination length	Examination language
Written exam	120 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students understand design-principles for modelling of software systems and the need for a systematic design-process. They are able to analyse concrete sets of tasks, apply problem-specific design methods, and model control software systems at an abstract level. They use standard methods and technologies to apply and implement models/designs using object-oriented or procedural programming languages.

Contents

- Basic concepts of object-oriented design: Classes, objects and interfaces, encapsulation, polymorphism, inheritance and delegation
- Object-oriented design with UML, use of elementary diagram types for modelling static and dynamic system aspects
- Fundamentals of Java programming
- Object-oriented implementation of software designs with Java
- Design of control systems in function block diagram language, RS- tables and sequential function charts in accordance with DIN EN 61131-3 as well as UML state diagrams
- Implementation of control designs on programmable logic controllers using the DIN EN 61131-3-Programmable Languages Instruction - List and Structured Text

Literature
• Lecture notes • Günther Wellenreuther, Automatisieren mit SPS, Vieweg-Verlag • Brügge, B. Dutoit, H. Objectoriented Softwareengineering using UML, Pattern, and Java: International Version , Publisher: Prentice Hall;
Special notes

Module 20

Control Systems 1

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 210 hrs 90 hrs attendance time (6 SWS) 90 hrs self-directed study time 30 hrs time for exam preparation	7

Responsible for module: Prof. Dr.-Ing. A. Ali

Lecturer(s):

Prof. Dr.-Ing. A. Ali, Prof. Dr. T. Kaupp, Prof. Dr. rer. nat. M. Mathes

Associated class(es)	Teaching and learning format	Language of instruction
Control Systems 1 (4 SWS)	Seminar-like lectures, Exercise course	English
Control Systems Lab 1 (2 SWS)	Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module , 4th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language
Written exam	90 min	English

plus: other examination requirements in accordance with §15a of the study and examination regulations (format: practical assignment)

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are familiar with the main structure and mode of action of a control device. They learn about the different processes of defining control loop elements and are able to assess these in respect of their dynamic behaviour. They can define simple systems in the time and image domain and develop a plan of action and resulting simulation model for the control loop. They understand how a PID controller works, they are familiar with analytical, empirical and computer-aided process control designs, and are able to apply what they have learned to simple practical examples.

Contents

- Introduction to control systems - principles of feedforward and feedback control, basic concepts, control loop
- Classification and behaviour of control loop elements, system properties, derivation of system equations, step response, transfer function, frequency response, coupled systems, block diagrams of control systems
- The controller - classification of controllers, PID control, implementation of control algorithms
- The control loop – control loop requirements, proof of stability, dynamic and steady-state behaviour
- Design methods for PID controllers - analytical methods (frequency-domain method, root-locus and pole-placement based methods), empirical methods, computer-aided design, model-based control, assessment of control loop behaviour

Literature
• Åström , K. J.: PID-Controllers: theory, design and tuning, ISA: The Instrumentation, Systems, and Automation Society. 1995 • Åström , K. J. and Murray, R. M.: Feedback systems : an introduction for scientists and engineers, Princeton University Press, Woodstock, Oxfordshire 2008 • Mann, H., Schiffelgen, H., Froriep, R.: Einführung in die Regelungstechnik, 11.te Auflage, Hanser-Verlag 2009. • Föllinger, O.: Regelungstechnik-Einführung in die Methoden und ihre Anwendung,11.te Auflage, VDE-Verlag, 2013. • Zacher, S., Reuter, M.: "Regelungstechnik für Ingenieure", 14. Auflage, Springer Vieweg, 2014. • Dorf, R., Bishop, R.:   Moderne Regelungssysteme, 10.te Auflage, Pearson Studium, 2006. • Notes to lectures in the FHWS eLearning system
Special notes

Module 21

Embedded Systems and Fieldbuses

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Summer semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs self-directed study time 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Eckert

Lecturer(s):

Prof. Dr.-Ing. Hansmann

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar-like lectures, Exercise course, Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module , 4th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Mathematics (M) and Electrical Engineering (ET) modules

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are familiar with the latest embedded systems, commercially available real-time operating systems and the architectures of microcontrollers and DSPs. They understand the structure and communication principles of fieldbuses.

Students are able to compare and interpret different embedded structures. They can classify and analyse fieldbus systems.

Students of this module are able to select and design appropriate embedded systems, and so realise real-time applications. They are able to select appropriate fieldbus systems and set its parameters.

Contents

1. **Embedded Systems**
   - Requirements of embedded systems and fundamental mechatronics functional groups: Mechanics, sensors, information processing, actuators
   - Interaction of mechatronics functional groups in simple applications
   - Architecture of microcontroller and DSPs, hardware/software co-design
   - Embedded development, test and verification environments
   - Architecture and structure of real-time operating systems, processor and resource management processes, synchronisation and communication methods, interrupt and time services
2. **Fieldbus systems**
   - Field devices
   - Signal transmission and transmission media
   - Connection structures and bus access
   - Profibus, CAN, Interbus, ASi, EIB/KNX

Literature

- Lecture notes with exercises
- Course books, e.g. Schnell, Gerhard; Bussysteme in der Automatisierungs- und Prozesstechnik, Verlag Vieweg Friedr. + Sohn 2006
- Klaus Wüst: Mikroprozessortechnik: Grundlagen, Architekturen, Schaltungstechnik und Betrieb von Mikroprozessoren und Mikrocontrollern, Verlag Springer 2010
- Helmut Bähring: Anwendungsorientierte Mikroprozessoren: Mikrocontroller und Digitale Signalprozessoren, Vieweg+Teubner Verlag, 2011

Special notes

Module 22

System Theory and Control Systems 2

Module length	Frequency	Workload	ECTS Credit Points
2 semesters	Summer semester	Total: 150 hrs 60 hrs attendance time (4 SWS) 60 hrs independent study 30 hrs time for exam preparation	5

Responsible for module: Prof. Dr.-Ing. Wilke, Prof. Dr. rer. nat. Hirn

Lecturer(s):
Prof. Dr.-Ing. Kharitonov, Prof. Dr.-Ing. B. Müller

Associated class(es)	Teaching and learning format	Language of instruction
System Theory (4th semester) 2 SWS	Seminar-like lectures	English
Control Systems 2 (5th semester) 2 SWS	Seminar-like lectures	English

Applicability and semester in accordance with the appendix to the study and examination regulations:
Mechatronics Bachelor's degree programme (core module , 4th and 5th semesters)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge
Passed in the subject areas of mathematics, physics, electrical engineering and control systems 1

Examination type	Examination length	Examination language
Written exam	90 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives
Students understand the fundamentals of system theory, the concept of state space control and the structure of digital controllers and are able to explain and design them. They can also analyse technical systems and develop mathematical models for abstraction so that they can investigate system behaviour independent of

the technical realisation of the system. To this end, they are able to schedule targeted work tasks and implement them in practice. They are able to argue their proposed solutions clearly.
Contents
• Elementary signals • Linear, time-invariant systems • Integral transforms (Laplace, Fourier, z-transforms, DFT, FFT) • Spectrum analysis • Transfer functions • State space representation, controllability and observability • State space control • Observers and model-based controllers • Digital control

Literature

- Oppenheim, Alan V.; Willsksy, Alan S.: Signals and Systems, Pearson Education Ltd. 2nd Edition, Harlow, 2013
- Giron-Sierra, Jose Maria: Digital Signal Processing with Matlab Examples 1, Springer Verlag, Berlin, 2016
- Werner, Martin; Digitale Signalverarbeitung mit MATLAB, Vieweg+Teubner, Wiesbaden 2012
- B.P. Lathi, „Linear Systems and Signals“, 2. Edition, Oxford University Press, 2005
- Unbehauen, Heinz; Regelungstechnik II: Zustandsregelungen, digitale und nichtlineare Regelsysteme, Vieweg+Teubner, Wiesbaden 2007
- Burns, Roland; Advanced Control Engineering, Butterworth-Heinemann, Oxford 2001
- Notes to lectures in the FHWS eLearning system

Special notes

Module 23

Design and Simulation of Mechatronic Systems

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Winter semester	Total: 210 hrs 75 hrs attendance time (5 SWS) 80 hrs self-directed study time 55 hrs time for exam preparation	7

Responsible for module: Prof. Dr.-Ing. C. Latour

Lecturer(s):

Prof. Dr.-Ing. C. Latour

Associated class(es)	Teaching and learning format	Language of instruction
Design and simulation of mechatronic systems	Seminar-like lectures, Exercise course Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 5th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Active knowledge of the subject areas of computing, engineering mathematics, physics, electrical engineering and mechanical engineering as part of the FHWS Mechatronics bachelor's degree programme

Examination type	Examination length	Examination language
Written exam	90 min	English

plus: other examination requirements in accordance with §15a of the study and examination regulations (format: practical assignment)

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are familiar with the analogies between standard physical parameters, descriptive equations and the circuitries of electrical, mechanical and fluid-based transmission components, and are able to create key interrelationships. They are also able to convert informally described causal chains from mechatronic partial and full systems into mathematical models, and describe these using selected modelling tools. They understand the effect of simulation and model parameters and are able to use them in a targeted way. They are also able to test simulation results in terms of plausibility and quantitatively assess the effect of model simplifications (e.g. linearisations). Students are able to apply selected techniques for developing simulation models for mechatronic systems and also understand the limits of their use.

Contents

- Analogies between electrical, mechanical and fluid-based systems in accordance with the potential flow and transversal system
- Standardised process of system model design with energy, mass and information flows
- Frequently occurring non-linearities
- Application examples of linear and non-linear mechatronic systems with electrical, mechanical and fluid-based subsystems

Literature
• Rolf Isermann, Mechatronic Systems, Springer, Berlin Heidelberg New York, 1st Edition 2005 • Rainer Nollau, Modellbildung und Simulation technischer Systeme, Springer Dordrecht, 2009 • Jörg Kahlert, WinFACT User Manual, Engineering Office Dr. Kahlert, 2005 • Notes to lectures in the FHWS eLearning system
Special notes
• Part of the exercise course is carried out as simulation exercises in the FHWS computer room

Module 28

General Engineering Lab

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Each semester	Total: 180 hrs 75 hrs attendance time (5 SWS) 105 hrs self-directed study time	6

Responsible for module: General Engineering Lab Coordinator

Lecturer(s):

According to the list of practical experiments (eLearning course)

Associated class(es)	Teaching and learning format	Language of instruction
Attendance at a total of 15 experiments during the course of the programme, of which maximum eight experiments during the first three semesters	Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics bachelor's degree programme (core module, nominally assigned to the 7th semester)

Conditions of participation in accordance with study and examination regulations

Proof of completing the 'Occupational Safety' course in the first semester

Recommended conditions of participation and prior knowledge

The recommended condition of participation and prior knowledge can be found in the individual practical experiment descriptions.

Examination type	Examination length	Examination language
Other examined assignment in accordance with §15a of the study and examination regulations (format: practical assignment)	---	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are able to apply what they have learned from other modules of the degree programme to an experiment, and can first identify the relevant knowledge learned in different modules and link it across disciplines to perform experiments successfully. They are thus able to apply scientific principles to analyse the processes and methods that are relevant to the experiment.
Students can plan and perform experiments and produce accurate scientific documentation of the results and methods. They are able interpret the experiment results and draw well-founded conclusions from them.
The specific learning objectives can be found in the descriptions of the individual practical experiments.

Contents

The content can be found in the descriptions of the individual experiments. The experiments involving different areas of mechatronics are offered by all the laboratories of the Faculty of Electrical Engineering and the Faculty of Mechanical Engineering (list of laboratories can be found in the laboratory handbook). Experiments related to natural sciences (e.g. physics, chemistry) are also offered.

Literature
Experiment instructions, lab manuals, lecture notes and additional documentation in the FHWS eLearning system.
Special notes

Module 29

Engineering Project

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Each semester	Total: 210 hrs 60 hrs attendance time (4 SWS) 150 hrs independent study	7

Responsible for module: Prof. Dr.-Ing. U. Müller, Prof. Dr. rer. nat. Hirn

Lecturer(s):

All professors of the Faculties of Electrical and Mechanical Engineering

Associated class(es)	Teaching and learning format	Language of instruction
Engineering Project	Seminar-like lectures, exercise course, lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module , 7th semester)

Conditions of participation in accordance with study and examination regulations

Min. 90 CP achieved before the Engineering Project is issued

Recommended conditions of participation and prior knowledge

All courses from the first to the sixth semester in this bachelor's degree programme

Examination type	Examination length	Examination language
Engineering project in accordance with §9 study and examination regulations (comprising tests in support of the project, final presentation and project documentation)	Parallel to the studies of the 7th semester	English/German

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students learn and expand their knowledge of project management and are able to structure a real development assignment in project phases. By using the methodical development approach and regarding technology, costs and the environment they learn how to fully assess a product, a system or a process and will be able to redesign it on the basis of a real assignment. Dealing with this task they work partly under supervision and partly independently. Utilizing the methodical development and project management, students apply scientific methods to a real development example by assessing, choosing and using various project management methods partly under supervision and partly independently. Furthermore, students are able to plan and carry out a project both technically and methodologically by working partially independently and partially in coordination with other project participants. Additionally, the students are responsible for project controlling.
Students are also able to present specialist content clearly and in an appropriate way for the target audience in verbal or written form. They are also able to put forward arguments to support project outcome.
As well as developing their technical and methodological knowledge, the engineering project improves the students' social skills.

Contents
For the engineering project, students independently apply their knowledge acquired through other modules of the bachelor's degree programme (specialist knowledge, methods and processes). They learn project management methods and apply these, under supervision, to real assignments working in teams. This engineering project also ensures that all students apply the latest research and technology of a single or multiple fields, and thus expand their knowledge independently. The project subject is a current R&D topic selected from industry or selected from recognised FHWS research projects. Dealing with it methods of methodological development are applied. To further advanced understanding of the techniques of scientific work, students are required to prepare a written project documentation in the form of a report and a verbal multimedia presentation of the project results.
Literature
• Lecture notes to 'Project management for the Mechanical Engineering degree programme' Volume 1 and Volume 2 (available in the eLearning system) • Engineering Design, A Systematic Approach, G. Pahl, W. Beitz, J. Feldhusen, K.H. Grote, Springer-Verlag, 2007 • VDI-Richtlinie 2222, Konstruktionsmethodik - Methodisches Entwickeln von Lösungsprinzipien, Ausgabedatum 06/1997, Verein Deutscher Ingenieure e.V., Düsseldorf • Methodisches Entwickeln technischer Produkte, U. Lindemann, 1. Aufl., Springer-Verlag 2005 • Notes to lectures in the FHWS eLearning system
Special notes
The interim presentation is usually held at the industry partner’s location. In this interim presentation, the students present the project results achieved until then to the industry or research partner under real-life conditions.

Subject Area: Bachelor's Thesis

Responsible for subject area: Faculty of Mechanical Engineering, Dean of Studies

Module 30

Bachelor's Thesis

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Each semester	Total: 360 hrs Attendance time at FHWS (meetings with supervisor) as required, approx. 6 hrs 354 hrs of independent study	12

Responsible for module: Dean of Studies

Lecturer(s):

Supervisor appointed by the examination committee (examiner)

Associated class(es)	Teaching and learning format	Language of instruction
	n/a	n/a

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module , 7th semester)

Conditions of participation in accordance with study and examination regulations

a) Internship (27) completed successfully, and
b) Control Systems 1 (20) module completed successfully,
c) at least 150 CP earned

Recommended conditions of participation and prior knowledge

Learning objectives of all the degree programme modules achieved

Examination type	Examination length	Examination language
Bachelor's Thesis in accordance with §11 of the study and examination regulations	Completion period if completed in one continuous period, generally two months (see Special Notes for further details)	English/German

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are able to apply their know-how and methodological knowledge independently, and across subjects/modules, to a real-world problem. They develop an engineering solution built on scientific foundations. They are also able to assess the effects of scientific engineering solutions on society and the ecology. They work according to professional ethics and standards.

They are able to critically assess their knowledge and take personal responsibility to improve it. They reflect critically on their own work and are able to apply project management methods in order to achieve the desired target in a limited time and with limited resources and budget. They are able to adapt themselves to new environments, e.g. of a company. Students are able to present their results and methods clearly in a written technical report and in accordance with scientific principles.

Contents
Solving an engineering problem from the field of mechatronics independently on scientific foundations
Literature
• Relevant literature in accordance with the topic of the Bachelor's thesis • Balzert et al.: Wissenschaftliches Arbeiten. W3L GmbH, 2. Auflage, 2011. • Hering, Hering: Technische Berichte. W3L GmbH, 7. Auflage, 2015.
Special notes
• The completion period from the topic being set to the submission of the Bachelor’s thesis may not exceed three months.   ○ Exception: If the Bachelor’s thesis is assigned no later than one month after the start of the 7th semester, this period must not exceed five months. • With the agreement of the examination committee, the Bachelor’s thesis may be completed in an institution outside the university if supervision by the university’s examiners is guaranteed.

Module 31

Bachelor's Seminar

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Each semester	Total: 150 hrs 45 hrs attendance time (3 SWS) 105 hrs self-directed study time	5

Responsible for module: Prof. Dr.-Ing. A. Ali

Lecturer(s):

All FE and FM professors

Associated class(es)	Teaching and learning format	Language of instruction
	Seminar	English or German

Applicability and semester in accordance with the appendix to the study and examination regulations:

Bachelor's degree programme Mechatronics (core module , 7th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Multimedia presentation and delivery techniques

Examination type	Examination length	Examination language
Other examined assignment in accordance with §15a of the study and examination regulations, format: Multimedia presentation (seminar)	---	English or German

Special admission requirements: Compulsory attendance on the seminar dates in accordance with the appendix to the study and examination regulations

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are able to prepare well-founded presentations during and on completion of their own Bachelor's thesis, and deliver these to the seminar participants. As seminar participants, students analyse presentations given by other students and compare them to their own work with respect to the approach, contents and presentation technique. They draw conclusions from the guest lectures about their future professional career.
Participants are able to grasp central ideas of an engineering project proposal and can outline its essential contents. Based on the state of the art or knowledge in the specific field, the students can describe the main and sub-goals of the project, plan them in time and present the methods to be used.
Students develop their personal and social skills and so improve their ability to prepare technical reports and presentations, collaborate in groups, take part in meetings and give feedback to other participants.

Contents

- Lectures, multimedia presentations and preparation of the synopsis/exposé of the proposed bachelor's thesis.

Literature

- H. Balzert et al.: Wissenschaftliches Arbeiten. W3L GmbH, 2. Auflage, 2011.
- Documents in the FHWS eLearning system

Special notes

- Guest lecturers from industry

4 Second Part of Studies, 6th Semester (Internship Semester)

Subject Area: Internship

Responsible for subject area: Internship coordinator

Module 26			
Practice-Related Courses			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Each semester	Total: 180 hrs 90 hrs attendance time (6 SWS) 70 hrs self-directed study time 20 hrs time for exam preparation	6
Responsible for module: Internship coordinator			
Lecturer(s):			
Internship Seminar: Professors and lecturers from the Faculties of Electrical Engineering and Mechanical Engineering Business Administration: Professors and lecturers from the Faculty of Business Engineering			
Associated class(es)		**Teaching and learning format**	**Language of instruction**
Internship Seminar (2 SWS)		Seminar	English / German
Business Administration (4 SWS)		Seminar-like lectures, Exercise course	English / German
Applicability and semester in accordance with the appendix to the study and examination regulations:			
Mechatronics Bachelor's degree programme (core module, 6th semester)			
Conditions of participation in accordance with study and examination regulations			
Recommended conditions of participation and prior knowledge			

Examination type	**Examination length**	**Examination language**
Internship Seminar: Other examined assignment in accordance with §15a of the study and examination regulations, format: Multimedia presentation (seminar) Business Administration: Written exam does not contribute to the final grade	90 min	English / German
Special admission requirements: Compulsory attendance at the Internship Seminars in accordance with the appendix to the study and examination regulations **Credit Points will be awarded only on successful completion of the examination!**		

Learning objectives

The practice-related courses supplement the internship by building on strengths that have become very important in engineers' daily professional lives, in addition to their engineering qualifications.
Internship Seminar:
Students learn soft skills by giving multimedia presentations on technical topics from the internship, discussing these in the group, and writing technical reports. The seminar thus provides an opportunity to exchange experience.
Business Administration:
On completion of the module, students are familiar with basic business administration relations. They are able to assess economic policy developments and decisions. Students are able to identify business problems in an engineer's daily working life and assess business administration issues.
The module teaches students basic knowledge of cost and performance accounting, leading to an understanding of this field. They develop an understanding of processes and communication skills in the relevant aspects of cost and benefit accounting.

Contents

Internship Seminar:

- Students exchange of experiences during the internship
- Teaching of soft skills through giving multimedia presentations and by drafting technical reports of personal activities during the internship

Business Administration:

- Business Administration
  - Constitutive operational decisions: Decision theory, location, legal structure, collaboration
  - Operational corporate management: Controlling, organisation, HR Department
  - Operational service delivery: Innovation, materials management
- Managerial Accounting (Cost and activity accounting)
  - Application-related teaching of various managerial accounting methods
  - Focus areas: Cost types, cost centres and cost unit accounting, full-cost and part-cost accounting, cost analysis

Literature

Internship Seminar:
L. Hering, H. Hering: Technische Berichte, Vieweg + Teubner-Verlag, 2009
Notes to lectures in the FHWS eLearning system
Business Administration:
Nickels, W./McHugh, J./McHugh, S.: Business: Connecting Principles to Pratice, latest edition, McGraw-Hill Companies
Wessels, W. J.: Economics, latest edition, Barron's Educational Series Inc. Hauppauge.
Vahs, D. / Schäfer-Kunz, J: Einführung in die Betriebswirtschaftslehre, 5. Auflage, 2007
Plinke, W. / Rese, M. / Utzig, B.P.: Industrielle Kostenrechnung, Eine Einführung, 8. Auflage, 2015
Friedl, G./ Hofmann, C./ Pedell, B.: Kostenrechnung, Eine entscheidungsorientierte Einführung, 2. Auflage, 2013

Special notes

Module 27

Internship

Module length	Frequency	Workload	ECTS Credit Points
1 semester	Each semester	Total: 720 hrs 0 SWS (at FHWS) 670 hrs attendance time (industry) 50 hrs of preparation for the industry internship	24

Responsible for module: Internship coordinator

Lecturer(s):

n/a

Associated class(es)	Teaching and learning format	Language of instruction
	n/a	n/a

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (core module, 6th semester)

Conditions of participation in accordance with study and examination regulations

90 CP at the beginning of the internship

Recommended conditions of participation and prior knowledge

Examination type	Examination length	Examination language

Credit Points will be awarded only after the submission of evidence of successful completion of the internship in the form of an internship certificate!

Learning objectives

Students transfer the engineering knowledge they have acquired by applying it in practice under the supervision of engineers.

Contents

The internship guidelines describe the requirements in the degree programme's internship.

Literature

Special notes

5 Second Part of Studies, Core Electives (Module no. 24 and 25)

5.1 Mechatronics in Automotive Engineering

Mechatronics in Automotive Engineering			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 120 hrs self-directed study time 60 hrs time for exam preparation	10
Responsible for module: Prof. Dr.-Ing. Schlachter			
Lecturer(s):			
Prof. Dr.-Ing. Dürr, Prof. Dr.-Ing. Schlachter			

Associated class(es)	**Teaching and learning format**	**Language of instruction**
Mechatronic Systems in Automotive Engineering (2 SWS)	Seminar-like lectures	English
Sensors and Actuators in Automotive Engineering (2 SWS)	Seminar-like lectures, Exercise course	English
Fundamentals of Vehicle Drives (2 SWS)	Seminar-like lectures, Exercise course	English
Lab course (2 SWS)	Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (elective module, 5th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Successful completion of all modules in the orientation phase as well as modules 17, 18, 19, 20 and 21

Examination type	**Examination length**	**Examination language**
Written exam	120 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

On completion of the course, students understand the fundamental concepts of mechatronics in automotive engineering. They are familiar with the physical operating principles of the sensors and actuators used in the automotive industry. Using advanced examples, students come to understand a range of mechatronic subsystems used in automotive engineering. They are able to experiment in examining vehicles and vehicle components. Students know the key requirements of vehicle drives as well as their design and how they function. They are able to evaluate the fundamentals challenges for vehicle drives of the future.

Contents

The content can be found in the individual course descriptions.

Literature

The literature references can be found in the individual course descriptions

Special notes

Course
Mechatronic Systems in Automotive Engineering
Lecturer(s):
Prof. Dr.-Ing. Dürr
Contents
• Application examples of mechatronic systems in automotive engineering (ABS, ASR, ESP, diesel injection technology, chassis control, driver assistance systems) • Insight into mechatronic system development methods
Literature
• Robert Bosch GmbH (Hrsg.): Sicherheits- und Komfortsysteme, Vieweg, 2004 • Robert Bosch GmbH (Hrsg.): Dieselmotor-Management, Springer Vieweg Burckardt,M.: Fahrwerktechnik: Radschlupf-Regelsysteme, Vogel-Verlag, 1993 • Isermann, R. : Fahrdynamik-Regelung, Vieweg, 2006 • Reif, K.: Automobilelektronik, Springer,2014 • Winner, H.: Handbuch Fahrerassistenzsysteme, Springer, 2015 • Notes to lectures in the FHWS eLearning system
Special notes

Course
Sensors and Actuators in Automotive Engineering
Lecturer(s):
Prof. Dr.-Ing. Dürr
Contents
• Physical fundamentals of sensors • Physical fundamentals of small drive actuators • Application examples
Literature
• Butzmann, St.: Sensorik in der Kraftfahrzeugtechnik, expert-Verlag, 2006 • Notes to lectures in the FHWS eLearning system
Special notes

Course
Fundamentals of Vehicle Drives
Lecturer(s):
Prof. Dr.-Ing. Schlachter
Contents
• Vehicle drive requirements • Driving resistance and practical calculation of driving cycles • Drive train requirements • The combustion engine as a vehicle drive • How four-stroke engines work • Engine control requirements • Mechanical and thermodynamic fundamentals of combustion engines • Hybrid drives • CAN Bus
Literature
• Seiffert, U.: Vieweg Handbuch Kraftfahrzeugtechnik, Vieweg+Teubner, 7. Auflage 2013 • Isermann, R.: Elektronisches Management motorischer Fahrzeugantriebe, Vieweg+Teubner, 1. Auflage 2010 • Notes to lectures in the FHWS eLearning system
Special notes
Students conduct driving resistance analyses individually or with their personal vehicle.

Course
Lab course
Lecturer(s):
Prof. Dr.-Ing. Dürr, Prof. Dr.-Ing. Schlachter
Contents
• Practical experiments in the area of 'Mechatronics in Automotive Engineering'

5.2 Thermal and Fluid Mechanical Simulation in Mechatronics

Thermal and Fluid Mechanical Simulation in Mechatronics			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 120 hrs self-directed study time 60 hrs time for exam preparation	10
Responsible for module: Prof. Dr.-Ing. Paulus			
Lecturer(s):			
Prof. Dr.-Ing. Paulus, Prof. Dr.-Ing. Blotevogel, Prof. Dr.-Ing. Möbus			
Associated class(es)		**Teaching and learning format**	**Language of instruction**
Applied Mechatronic Systems (1 SWS)		Seminar-like lectures	English
Fundamentals of Thermodynamics, Heat Transfer, Fluid Mechanics (3 SWS)		Seminar-like lectures, Exercise course	English
Numerical Simulation (4 SWS)		Seminar-like lectures, Exercise course, Lab course	English
Applicability and semester in accordance with the appendix to the study and examination regulations:			
Mechatronics Bachelor's degree programme (elective module, 5th semester)			
Conditions of participation in accordance with study and examination regulations			
Recommended conditions of participation and prior knowledge			
Engineering mathematics, numerical mathematics, engineering mechanics			

Examination type	**Examination length**	**Examination language**
Written exam	120 min	English
Credit Points will be awarded only on successful completion of the examination!		

Learning objectives
Students are familiar with the fundamentals of thermodynamics, heat transfer and fluid mechanics as required to understand flow and heat transfer processes. They are able to apply this knowledge to assignments. Students are familiar with the principle of discretisation and understand its application in simulation software. They are able to set up simulations models for flow and heat transfer problems themselves and assess possibilities and limits of use.
Contents
The content can be found in the individual course descriptions.
Literature
The literature references can be found in the individual course descriptions
Special notes

Course
Mechatronic Systems in Systems Engineering
Lecturer(s):
Prof. Dr.-Ing. Paulus
Contents
• Examples of applications of mechatronic systems in industry • System behaviour of parts, equipment and components as required for the design of mechatronic systems.
Literature
• Notes to lectures in the FHWS eLearning system
Special notes
• Excursions and guest lectures on systems

Course
Fundamentals of Thermodynamics, Heat Transfer, Flow Mechanics
Lecturer(s):
Prof. Dr.-Ing. Paulus, Prof. Dr.-Ing. Blotevogel, Prof. Dr.-Ing. Möbus
Contents
• Thermodynamics: Fundamental concepts, first law of thermodynamics, ideal gas, cyclical processes with ideal gas as the working material • Heat transfer: Thermal conduction, convection, thermal radiation, combination of the three types of heat transfer, heating and cooling processes of bodies • Flow mechanics: Conservation of mass and momentum, flow filament theory, similarity theory
Literature
• Baehr, Kabelac: Thermodynamik. Grundlagen und technische Anwendungen. 15. Auflage, Springer Vieweg 2012. • Labuhn, Romberg: Keine Panik vor Thermodynamik. 6. Auflage, Springer Vieweg 2012. • Cerbe, Wilhelms: Technische Thermodynamik. Theoretische Grundlagen und praktische Anwendungen. 17. Auflage, Hanser 2013. • Wagner: Wärmeübertragung. 7. Auflage, Vogel 2011. • Baehr, Stephan: Wärme- und Stoffübertragung. Bohl, W., Elmendorf, E.: "Technische Strömungslehre", Vogel Verlag, 2014 • Notes to lectures in the FHWS eLearning system
Special notes

Course
Numerical Simulation
Lecturer(s):
Prof. Dr.-Ing. Paulus, Prof. Dr.-Ing. Möbus
Contents
• Multiphysics simulations • Structure and optimisation of models, comparison with experiments • Coupled simulations of e.g. thermoelectric phenomena • Flow simulation (Computational Fluid Dynamics, CFD): • Finite volume discretisation, iterative solution of systems of equations • Pressure-velocity coupling with incompressible flow • Turbulence modelling (RANS, LES, DNS) • Practical exercises with CFD software
Literature
• Schwarze, R.: "CFD-Modellierung", Springer Verlag, 2013 • Versteeg, H.K., Malalasekera, W.: "Computational Fluid Dynamics", Pearson Verlag, 2007 • Notes to lectures in the FHWS eLearning system
Special notes

5.3 Measurement Techniques and Design of Experiments for Mechatronic Systems

Measurement Techniques and Design of Experiments for Mechatronic Systems			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 120 hrs self-directed study time 60 hrs time for exam preparation	10
Responsible for module: Prof. Dr.-Ing. Schreiber			
Lecturer(s):			
Prof. Dr.-Ing. Schreiber, Prof. Dr. Sommer, Prof. Dr.-Ing. Wilke			
Associated class(es)		**Teaching and learning format**	**Language of instruction**
Design of Experiments (3 SWS)		Seminar-like lectures, Exercise course	English
Industrial Measurement Techniques (3 SWS)		Seminar-like lectures, Exercise course	English
Industrial Sensors and Signal Processing (2 SWS)		Seminar-like lectures	English
Applicability and semester in accordance with the appendix to the study and examination regulations:			
Mechatronics Bachelor's degree programme (elective module, 5th semester)			
Conditions of participation in accordance with study and examination regulations			
Recommended conditions of participation and prior knowledge			
Successful completion of the previous semesters' courses			

Examination type	**Examination length**	**Examination language**
Written exam	135 min	English
Credit Points will be awarded only on successful completion of the examination!		

Learning outcomes
Participants understand the structure and configuration of mechatronic measurement techniques in industrial processes. They are able to systematically analyse mechatronic (measurement) systems. The students use a designated software package to design state of the art experiment plans and to assess the experiment results. The specialist expertise acquired enables students to develop mechatronic measurement processes and apply these in an industrial environment. Participants understand the concepts of error-free production, and are able to verify industrial measurement and manufacturing processes.
Contents
The contents is listed in the individual course descriptions.
Literature
The literature references are given in the individual course descriptions
Special notes

Course
Design of Experiments
Lecturer(s):
Prof. Dr.-Ing. Schreiber
Contents
On completion of the course, students are familiar with the scientific methods of computational and experimental system analysis, in particular statistically sound planning and evaluation of experiments (Design of Experiments, DoE). They are able to apply this knowledge to basic practical assignments. Students are then capable to assess the effects of control factors and noise factors upon the systems under consideration.
Literature
• Kleppmann, Wilhelm: Versuchsplanung: Produkte und Prozesse optimieren (German), Hanser Verlag, 9th edition (2016) • Storm, Regina: Wahrscheinlichkeitsrechnung, mathematische Statistik und statistische Qualitätskontrolle (German), Hanser Verlag, 12th edition (2007) • Notes to lectures in the FHWS eLearning system
Special notes

Course
Industrial Measurement Techniques
Lecturer(s):
Prof. Dr.-Ing. Sommer
Contents
• Design and application of automatic measurement systems and processes to guarantee error-free production in industry.
Literature
• Hoffmann, J.: Taschenbuch der Messtechnik, Carl Hanser Verlag, 7. Aufl., München, 2015 • Sommer, Stephan: Taschenbuch automatisierte Montage- und Prüfsysteme, Hanser Verlag, 2008
Special notes
• e.g. practical exercises in the Laboratory for Quality Management, Production Metrology and Bearing Engineering

Course
Industrial Sensors and Signal Processing
Lecturer(s):
Prof. Dr.-Ing. Wilke
Contents
• Design and structure of industrial sensor systems • Design and structure of measurement signal transmission systems • Design and structure of industrial measurement signal processing systems • Concept development for industrial measurement systems • Design of industrial measurement systems
Literature
• Hoffmann, J.: Taschenbuch der Messtechnik, Carl Hanser Verlag, 7. Aufl., München, 2015 • Schrüfer, Elmar; Elektrische Messtechnik, Hanser, München 2007 • Gevatter, Hans-Jürgen; Grünhaupt, Ulrich: Handbuch der Mess- und Automatisierungstechnik in der Produktion, Springer Verlag, 2. Aufl. Berlin 2006 • Notes to lectures in the FHWS eLearning system
Special notes

5.4 Automation and Robotics

Automation and Robotics			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 120 hrs self-directed study time 60 hrs time for exam preparation	10
Responsible for module: Prof. Dr. Bernhard Müller			
Lecturer(s):			
Prof. Dr. Jan Hansmann, Prof. Dr. Tobias Kaupp, Prof. Dr. Bernhard Müller			
Associated class(es)		**Teaching and learning format**	**Language of instruction**
Digital Control (2 SWS)		Seminar-like lectures, Exercise course	English
Robotics (2 SWS)		Seminar-like lectures, Exercise course	English
Signal Processing (2 SWS)		Seminar-like lectures, Exercise course	English
Automation Lab (2 SWS)		Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (elective module, 5th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

- Completion of the following courses:
    - Control Systems 1
    - System Theory
    - Logic Control and Software Engineering
- Basic experience in preparation and documentation of lab exercises

Examination type	Examination length	Examination language
Written exam	120 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Control systems, robot control and digital signal processing are the key pillars of automation.
Students are able to specify common procedures and methods in these fields of knowledge and they are able to explain their principles of operation.
Students understand and discuss these methods. Furthermore, they are able to distinguish between them and to structure them.
Students are able to apply the learned procedures and methods to given applications by using suitable modifications if necessary. Moreover, they can verify and assess the results.
The *Digital Control* course introduces the design, implementation and analysis of digital control systems.
Robotics teaches the fundamentals of industrial and collaborative robots.
In *Signal Processing* students gain basic understanding of signal analysis and filter design methods.
Theoretical knowledge is applied and assessed in the *Automation Lab* course.

Contents

see descriptions of the individual courses

Literature

see descriptions of the individual courses

Special notes

Course

Digital Control

Lecturer(s):

Prof. Dr.-Ing. Bernhard Müller

Contents

- Introduction to digital control (discrete-time control systems)
  - Important terms, structures, components
- Indirect controller design approach
  - Discretization of continuous-time control laws
  - Implementation issues
- Mathematical description and analysis of closed-loop system with digital controller
  - Mathematical modelling of sampling process
  - Discussion of sampled signals in the frequency domain
  - Shannon's sampling theorem
- State space description of discrete-time systems
  - General form of linear time-invariant state space equations
  - Important properties (stability, controllability, observability)
  - Derivation of discrete-time description of sampled system
- Discrete-time state feedback control
  - State feedback controller design
  - Observer design
  - Disturbance rejection

Literature

- Lecture notes
- Phillips, C. L.; Nagle, H. T., Chakrabortty, A: Digital Control System Analysis and Design. 4th ed., Pearson, 2015.
- Franklin, G. F.; Powell, J. D., Workman, M.: Digital Control of Dynamic Systems. 3rd ed., Ellis-Kagle Press, 2006.
- Oppenheim, A. V., Schafer, R. W.: Discrete-time signal processing. 3rd ed., Prentice Hall, 2010.

Special notes

Course
Robotics
Lecturer(s):
Prof. Dr. Tobias Kaupp
Contents
• Mechanical and electrical components of industrial robots • Kinematics of common industrial robots: articulated arm, Scara and gantry robots • Typical applications for industrial robots (e.g. handling, processing), specific requirements • Fundamentals of robot control: coordinate system transformations with matrices, forward and inverse transformation, Denavit-Hartenberg convention • Interpolation methods for motion control (point-to-point and path control). • Programming languages and programming techniques for industrial robots (teaching, off-line programming) • Vision-controlled robot systems • Collaborative robots
Literature
• Lecture reprint • Reza N. Jazar, Theory of Applied Robotics (2nd Edition), Springer Science+Business Media, 2010 • Weber, Industrieroboter, Fachbuchverlag Leipzig, 2009
Special notes

Course
Signal Processing
Lecturer(s):
Prof. Dr. Jan Hansmann
Contents
• Fundamental concepts of data communication • Knowledge on components, structure, and systems of common types of networks • ISO/OSI-layer model • Design methods in digital signal processing • Design and analysis of FIR and IIR filters • Spectral signal analysis
Literature
• Lecture notes • Meffert, B.; Hochmuth, O.; Werkzeuge der Signalverarbeitung. Pearson Studium, 2004
Special notes

Course
Automation Lab
Lecturer(s):
Prof. Dr. Jan Hansmann, Prof. Dr. Tobias Kaupp, Prof. Dr. Bernhard Müller
Contents
• Basic experiments with programmable logical controllers • Design, implementation and verification of logic control for an industrial manufacturing system model • Basic experiments for teaching and programming an industrial robot
Literature
• Lab course's exercises with descriptions • Lecture notes of the classes in the module "Automation and Robotics" • Lecture notes
Special notes

5.5 Embedded Systems and Processor Applications

Embedded Systems and Processor Applications			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 135 hrs of independent study 45 hrs time for exam preparation	10
Responsible for module: Prof. Dr. Heinz Endres			
Lecturer(s):			
Prof. Dr. Ludwig Eckert, Prof. Dr. Martin Spiertz, Prof. Dr. Gerhard Schormann, Prof. Dr. Heinz Endres			
Associated class(es)		**Teaching and learning format**	**Language of instruction**
Real-Time Operating Systems (2 SWS)		Seminar-like lectures, Exercise courses	English
Signal Processing Systems and Methods (2 SWS)		Seminar-like lectures, Exercise course	English
Circuit Design with VHDL (2 SWS)		Seminar-like lectures, Exercise course	English
Lab Course Processor Systems (2 SWS)		Lab course	English
Applicability and semester in accordance with the appendix to the study and examination regulations:			
Mechatronics Bachelor's degree programme (elective module, 5th semester)			
Conditions of participation in accordance with study and examination regulations			
Recommended conditions of participation and prior knowledge			
Basic knowledge of mathematics and microcomputer systems from first part of studies			

Examination type	Examination length	Examination language
Written exam	120 min	English
Credit Points will be awarded only on successful completion of the examination!		

Learning objectives

Students are familiar with different embedded system architectures, and understand the need for and functioning of real-time operating systems. They also acquire the ability to develop and implement real-time applications. Students are familiar with the possibilities of digital signal processing and the key processing algorithms. They understand the typical problems of signal processing and are able to solve them independently. Students are also familiar with the concepts of a hardware description language and are able to apply VHDL to small projects. The internship builds on the programmable microcontroller skills students have acquired on the foundation module, and they to learn how to programme DSP components.

Contents

The content can be found in the individual course descriptions.

Literature

The literature references can be found in the individual course descriptions

Course

Embedded System Architectures and Real-Time Operating Systems

Lecturer(s):

Prof. Dr. Ludwig Eckert

Contents

- Requirements of embedded systems
- Fundamental mechatronic function groups:
  Mechanics, sensors, actuators, information processing
- Interaction of mechatronics functional groups in simple applications
- Architecture of microcontroller and DSP processors, hardware/software co-design
- Embedded development, test and verification environments
- Architecture, requirements and structure of real-time operating systems, understanding of commercially available real-time operating systems, processor and resource management processes, synchronisation and communication methods, interrupt and time services
- Design and implementation of real-time applications

Literature

- Zöbel, D.; Albrecht, W.; Echtzeitsysteme - Grundlagen und Techniken, Echtzeitanalyse, Echtzeitprogrammierung; Informatik Lehrbuch Reihe, International Thomson Publishing, 1995
- Eberhard Kienzle und Jörg Friedrich; Programmierung von Echtzeitsystemen; Carl Hanser Verlag GmbH & Co. KG, 2008
- Heinz Wörn; Echtzeitsysteme: Grundlagen, Funktionsweisen, Anwendungen; Springer; Auflage 2005
- Allworth, Steve T.; Introduction To Real-Time Software Design; New York, New York, Springer-Verlag, 1981
- Klein, Mark H., Thomas Ralya, Bill Pollak, Ray Harbour Obenza, and Michael Gonzlez; A Practioner's Hardbook for Real-Time Analysis; Guide to Rate Monotonic Analysis for Real-Time Systems; Norwell, Massachusetts, Springer; Auflage: 1993
- Notes to lectures in the FHWS eLearning system

Special notes

- Guest lectures in the context of expert sessions, in collaboration with Mixed Mode GmbH, Munich

Course

Signal Processing Systems and Processes

Lecturer(s):

Prof. Martin Spiertz

Contents

- Signal types
- Sampling and reconstructing continuous signals
- Design and elements of a signal processing system
- Effects and their description
- Folding and differential equations
- z-transforms
- Frequency responses
- FIR and IIR filters and their designs
- Discrete Fourier transforms
- Spectrum analysis
- Stochastic signals and their processing

Literature

- Oppenheim, Alan V.; Schafer, Ronald W.; Buck, John R.: Zeitdiskrete Signalverarbeitung,
- 2. überarbeitete Aufl., Pearson Studium, München, 2004
- Meffert, B.; Hochmuth, O.: Werkzeuge der Signalverarbeitung, Pearson Studium, 2004
- Girod, B.; Rabenstein, R.; Stenger, A.: Einführung in die Systemtheorie, Teubner-Verlag, 2003

Special notes

- Guest lectures by industry lecturers, excursions, excursion to research-related institutions

Course

Circuit Design with VHDL

Lecturer(s):

Prof. Dr. Heinz Endres

Contents

- Fundamental elements of VHDL
- Test benches and simulation
- Sequential and combinatorial description
- Complex VHDL data types
- VHDL project development taking the example of an HDMI interface
- Structure and programming of an FPGA
- Hierarchical structure and configuration
- Libraries and packages

Literature

- J. Reichard, B. Schwarz, VHDL-Synthese, Oldenbourg Wissenschaftsverlag, 4. Auflage 2007.
- P.J. Ashenden, The Designer's Guide to VHDL, Morgan Kaufmann Publishers, San Francisco 2002.
- Institute of Electrical and Electronics Engineering, Inc. New York, IEEE Standard VHDL Language Reference Manual , 1987.
- Notes to lectures in the FHWS eLearning system

Course

Embedded Systems and Processor Applications Lab

Lecturer(s):

Prof. Dr. Gerhard Schormann, Prof. Dr. Ludwig Eckert

Contents
• Programming of microcontrollers • Programming of digital signal processors • Use of real-time operating systems
Literature
• Notes to lectures in the FHWS eLearning system

5.6 Communication and Network Technology

Communication and Network Technology			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 120 hrs self-directed study time 60 hrs time for exam preparation	10
Responsible for module: Prof. Ulrich Mann			
Lecturer(s):			
Prof. Dr.-Ing. Eckert, Prof. Dipl.-Ing. Ulrich Mann			
Associated class(es)		**Course**	**Language of instruction**
Network technology (2 SWS)		Seminar-like lectures	English
Communication networks – using and understanding them (2 SWS)		Seminar-like lectures, Exercise course	English
Network communication – fundamentals (2 SWS)		Seminar-like lectures, Exercise course	English
Lab course (2 SWS)		Lab course	English
Applicability and semester in accordance with the appendix to the study and examination regulations:			
Mechatronics Bachelor's degree programme (elective module, 5th semester)			
Conditions of participation in accordance with study and examination regulations			
Recommended conditions of participation and prior knowledge			

Examination type	**Examination length**	**Examination language**
Written exam	90 min	English
Credit Points will be awarded only on successful completion of the examination!		

Learning objectives
Students are able, · to understand the latest network communication processes, · design implementation concepts and adapt them appropriately to specific requirements, · correctly set transmission parameters, and · evaluate potential realisations with respect to transmission properties.
Contents
The content can be found in the individual course descriptions.
Literature
The literature references can be found in the individual course descriptions
Special notes

Course
Network Technology
Lecturer(s):
Prof. Dr.-Ing. L. Eckert
Contents
• ISO/OSI communication model (bit transmission layer, data transmission layer, etc.) • The Ethernet networking technology (bus access process) • Network design (structured cabling in buildings, permanent link, physical transmission parameters, release measurements) • Functioning of modern network components (OSI layer 1, OSI layer 2 and OSI layer 3 devices) • Tutorial - design of a network topology • Configuration of IP networks and IP address space concepts with minimum impact on resources (IP address space planning and subnetting, VLSM – Variable Length of Subnet Masking, CIDR - Classless Interdomain Routing) • Practical class - physical address space planning (subnetting/VLSM) • Communication within a local network and beyond the locale subnetwork • Network routing process and routing protocols • Practical class - network routing • Internet protocols and services (DHCP, ARP, DNS, TCP, UDP etc.)
Literature
• Lecture notes with exercises • Wendell Odom: Cisco CCNA Routing und Switching ICND2 200-101: Das offizielle Handbuch zur erfolgreichen Zertifizierung; dpunkt.verlag GmbH 2014 (german) • Comer, Douglas E.: Internetworking with TCP/IP, Vol.1: Principles, Protocols, and Architectures, Prentice Hall International 2000 • Douglas E. Comer: Computernetzwerke und Internets; Verlag Pearson Studium, Prentice Hall, 2000
Special notes

Course
Using and Understanding Communication Networks
Lecturer(s):
Prof. Dipl.-Ing. Ulrich Mann

Contents

Classic telecommunication networks

- ISDN
- GSM
- LTE
- DSL
- NGN (Next Generation Networks)
- Multimedia over IP
    - VoIP - communication scenarios
    - TCP, UDP, RTP, RTCP
    - SIP (Session Initiation Protocol) and SDP (Session Description Protocol)
    - SIP system architecture
    - SIP hardware and network components
    - Security and QoS (Quality of Service)
- The future of communication networks:
    - Network Functions Virtualisation (NFV)
    - Software Defined Networking (SDN)
    - Mobile Communication 4th and 5th generation

Literature

- SIP: Understanding the Session Initiation Protocol (Telecommunications Library) Hardcover – 1 Jan 2001 by Alan B. Johnston

Special notes

Course

Network Communication - Fundamentals

Lecturer(s):

Prof. Dipl.-Ing. Ulrich Mann

Contents

Transmission efficiency for high data rates

- Fundamental considerations of signals and their specific properties
- Regeneration of information signals
- Wireless signal transmission, strengths and weaknesses
- Wired signal transmission, strengths and weaknesses
- Noise and other reasons for transmission errors
- Signal quality and how to determine it
- Error reduction, error correction systems
- Applications and examples
- WLan 802.11, LTE, DSL, satellite

Literature

- "Mobile Wireless Communications", Mischa Schwartz, Cambridge University Press 2005
- "Wireless LANs", Jörg Rech, Heise Verlag, 2008 (german)

Special notes

Course
Lab Course
Lecturer(s):
Prof. Dr.-Ing. L. Eckert, Prof. Dipl.-Ing. U. Mann
Contents
• Practical experiments from the field of 'Communication and Network Technology'

5.7 Power Engineering and Electro-mobility

Power Engineering and Electro-mobility			
Module length	**Frequency**	**Workload**	**ECTS Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 120 hrs self-directed study time 60 hrs time for exam preparation	10
Responsible for module: Prof. Dr.-Ing. Kempkes			
Lecturer(s):			
Prof. Dr.-Ing. Kempkes, Prof. Dr.-Ing. Zink			

Associated class(es)	**Teaching and learning format**	**Language of instruction**
Electrical Traction Drives (2 SWS)	Seminar-like lectures	English
Introduction to Energy Distribution (4 SWS)	Seminar-like lectures, Exercise course	English
Lab course (2 SWS)	Lab course	English

Applicability and semester in accordance with the appendix to the study and examination regulations:

Mechatronics Bachelor's degree programme (elective module, 5th semester)

Conditions of participation in accordance with study and examination regulations

Recommended conditions of participation and prior knowledge

Examination type	**Examination length**	**Examination language**
Written exam	135 min	English

Credit Points will be awarded only on successful completion of the examination!

Learning objectives

Students are familiar with the physical operating principles, structure and functioning of the entire energy power conversion chain from the power plant to the vehicle with electric drive. They are able to derive the mathematical correlations to describe causal loops for selected drive systems and design these according to technical requirements. As such, they can analyse the technical requirements and plan the drive system based on the components. Students are able to schedule targeted work tasks and implement them in practice. They can critically evaluate the desired results.

Students are familiar with the design and operation of electrical energy networks, and are aware of the main types of power plant. They are able to work out simple energy networks, and they understand the key interrelationships between active power/frequency and voltage/power factor control.

Contents

The content can be found in the individual course descriptions.

Literature

The literature references can be found in the individual course descriptions

Special notes

The special notes can be found in the individual course descriptions.

Course
Introduction to Energy Distribution
Lecturer(s):
Prof. Dr.-Ing. Zink
Contents
• Design of energy networks (three-phase system, voltage levels, network types) • Power requirement (load profile) • Fundamentals of designing and operating energy networks (equivalent circuit diagrams, load flow calculation, active power/frequency and voltage/power factor control, different load situations) • Fundamentals of the structure of our electrical energy system, voltage types and levels • Fundamentals of active power/frequency and voltage/power factor control • Fundamentals of load flow calculation
Literature
• Corsi: Voltage control and protection in electrical power systems, Springer, 2015 • Schlabbach, Rofalski: Power system engineering, Wiley, 2014
Special notes
• Seminar lectures

Course
Electrical traction drives
Lecturer(s):
Prof. Dr.-Ing. Kempkes
Contents
• Selected aspects of power electronics (in particular DC-DC converters, inverters) • Transformers (T-equivalent circuit diagram, short circuit and short circuit voltage, three-phase transformers) • Synchronous motor (BLDC motor, three-phase transformer, vector diagram, reluctance, PM synchronous motor, speed adjustment) • Asynchronous motor (constructional design, Heyland/Ossanna circle, metrological determination of ESB sizes, speed adjustment) • Introduction to mobile energy storage systems and mobile energy management
Literature
• Hughes: Electric Motors and Drives: Fundamentals, Types and Applications, Newens, 4th ed., 2013 • Mohan et al.: Power Electronics, John Wiley & Sons, 3rd. ed., 2002
Special notes
Additional blended learning content on the FHWS eLearning platform to support self-directed study and exam preparation

Course
Lab Course
Lecturer(s):
Prof. Dr.-Ing. Kempkes
Contents
Advanced content from the 'Introduction to energy distribution' and 'Electrical traction drives' modules, based on appropriate practical experiments, e.g. • Buck converters • Phase angle control • Photovoltaic systems • Operational management of a wind farm
Literature
The literature references can be found in the 'Introduction to energy distribution' and 'Electrical traction drives' course descriptions.
Special notes
Additional blended learning content on the FHWS eLearning platform 'laboratory experiments preparation and follow-up' area

5.8 Cryptography and Digital Hardware Design

Modul 24/25 Core Elective			
Cryptography and Digital Hardware Design			
Module length	**Frequency**	**Workload**	**ECTS-Credit Points**
1 semester	Winter semester	Total: 300 hrs 120 hrs attendance time (8 SWS) 135 hrs of independent study 45 hrs time for exam preparation	10
Responsible for module: Prof. Ulrich Mann			
Lecturer(s):			
Prof. Ulrich Mann, Prof. Dr. Heinz Endres			
Associated class(es)		**Teaching and learning format**	**Language of instruction**
Cryptography and Hacking (4 SWS)		Seminar-like lectures, exercise courses, additional integrated lab courses	English
Hardware Description Languages (2 SWS)		Seminar-like lectures, exercise courses	English
Lab SystemVerilog Design with FPGAs (2 SWS)		Lab Course	English
Applicability and semester in accordance with the appendix to the study and examination regulations:			
Mechatronics Bachelor's degree programme (elective module, 5th semester)			
Conditions of participation in accordance with study and examination regulations			
None.			
Recommended conditions of participation and prior knowledge			
Basic knowledge of mathematics; basic programming knowledge, and content of lectures Microcomputer Systems 1 and 2.			

Examination Type	**Examination length**	**Examination language**
Written exam	120 min	English
Credit Points will be awarded only on successful completion of the examination!		

Learning objectives
Students are familiar with the basics of the science of cryptography. They get to know how programmers and network professionals can use cryptography to maintain the privacy of computer data. They also gain experience in the field of computer attacks to help them grow into a responsible role, capable of determining security and privacy problems and making proper security decisions for themselves. Students are familiar with the concepts of a hardware description language and can apply them to small and medium size projects. They also have experience in programming, verification and debugging FPGA devices.
Contents
The content can be found in the individual course descriptions.
Literature
The literature references can be found in the individual course descriptions.

Course
Cryptography and hacking
Lecturer(s):
Prof. Ulrich Mann

Contents

Cryptography:
- the origins of cryptography
- various traditional and modern ciphers,
- public key encryption,
- data integration,
- message authentication,
- and digital signatures.
- lab courses: RSA, diffie-helman, vigenère, etc.

Hacking / Penetration Testing:
- identifying systems and their services
- malware, viruses, worms, trojans, rootkits
- attack analysis,
- network communications
- network sniffing
- lab courses: wireshark, the „windows hack“, wlan-hacking, the „evil-twin“, etc.

Literature

Network Security Technologies and Solutions
A comprehensive, all-in-one reference for Cisco network security
Yusuf Bhaiji, CCIE No. 9305

The little black book of computer viruses / by Mark A. Ludwig

and all google's stuff

Course

Hardware Description Languages

Lecturer(s):

Prof Dr Heinz Endres

Content

- Basic elements and structure of SystemVerilog as a hardware design and verification language
- Test benches and simulation using object-oriented verification
- Description of sequential and combinatorial elements
- Programming of FPGA modules and complex SoCs
- Principles of static timing analysis
- Usage of different libraries and packages

Literature
• Donald Thomas, *Logic Design and Verification Using SystemVerilog*, CreateSpace Independent Publishing Platform, Revised Edition 2016 • Stuart Sutherland, *RTL Modeling with SystemVerilog for Simulation and Synthesis: Using SystemVerilog for ASIC and FPGA Design*, CreateSpace Independent Publishing Platform, First Edition 2017 • Institute of Electrical and Electronics Engineering, Inc. New York, 1800-2017 - *IEEE Standard for SystemVerilog Unified Hardware Design, Specification, and Verification Language*, Dec 2017 • Notes to lecture in the FHWS eLearning system

Course
Lab SystemVerilog Design with FPGAs
Lecturer(s):
Prof. Dr. Heinz Endres
Content
Different own experiments to program Xilinx SoCs, with focus on • FPGA control using SystemVerilog for both design and verification • Hand-on experiments debugging an STA (Static timing analysis) environment • Communication between ARM Cortex-A9 running on Linux operation system and FPGA based logic • Design examples for controlling an HDMI interface.
Literature
• Notes and descriptions of experiments if the FHWS eLearning system