
M.Sc. Electrical Engineering and Information Technology (PO 2014)

Automation Systems

Date: 01.10.2020



TECHNISCHE
UNIVERSITÄT
DARMSTADT

Department of Electrical Engineering
and Information Technology

Module manual: M.Sc. Electrical Engineering and Information Technology (PO 2014)
Automation Systems
Date: 01.10.2020

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Contents

1	Fundamentals	1
	System Dynamics and Automatic Control Systems III	1
	Digital Control Systems I	3
	Identification of Dynamic Systems	4
	Modeling and Simulation	6
	Laboratory Control Engineering II	7
2	Optional Modules	8
2.1	AUT I: Automatic Control Systems	8
	Digital Control Systems II	8
	Fuzzy Logic, Neural Networks and Evolutionary Algorithms	10
	Controller Design for Multivariable Systems in State Space	11
	Industrial Electronics	12
2.2	AUT II: Information Technology - Practical courses, seminars, project seminars	13
	Computer Vision in Engineering	13
	Power Electronics	15
	Materials of Electrical Engineering	17
	Numerical Methods for Ordinary Differential Equations for Engineers	18
	Numerical Linear Algebra	19
	Laboratory Matlab/Simulink II	20
	Project Seminar Automatic Control Systems	21
	Project Course Practical Application of Mechatronics	22
	Project Course Control Engineering	23
	Project Seminar Robotics and Computational Intelligence	24
	Computer Systems I	25
	Autonomous Driving Lab I	26
	Robust Control	28
	Matrix Analysis and Computations	29
	Machine Learning and Deep Learning for Automation Systems	31
2.3	AUT III: Thermodynamics and Fluid Dynamics	33
	Fundamental Fluid Mechanics	33
	Technical Thermodynamics I	34

1 Fundamentals

Module name System Dynamics and Automatic Control Systems III					
Module Nr. 18-ad-2010	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content Topics covered are: <ul style="list-style-type: none"> • basic properties of non-linear systems, • limit cycles and stability criteria, • non-linear control of linear systems, • non-linear control of non-linear systems, • observer design for non-linear systems 				
2	Learning objectives / Learning Outcomes After attending the lecture, a student is capable of: <ul style="list-style-type: none"> • explaining the fundamental differences between linear and non-linear systems, • testing non-linear systems for limit cycles, • stating different definitions of stability and testing the stability of equilibria, • recalling the pros and cons of non-linear controllers for linear systems, • recalling and applying different techniques for controller design for non-linear systems, • designing observers for non-linear systems 				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100%) 				
6	Usability of this module MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik				
7	Grade bonus compliant to §25 (2)				
8	References Adamy: Systemdynamik und Regelungstechnik III (available for purchase at the FG office)				
Courses					
	Course Nr. 18-ad-2010-vl	Course name System Dynamics and Automatic Control Systems III			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Lecture	SWS 2

	Course Nr. 18-ad-2010-ue	Course name System Dynamics and Automatic Control Systems III		
	Instructor Prof. Dr.-Ing. Jürgen Adamy		Type Practice	SWS 1

Module name Digital Control Systems I					
Module Nr. 18-ko-2020	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content Theoretical fundamentals of sampled control systems: Discrete-time functions, sample/hold element, z-transform, convolution sum, z-transfer function, stability of sampled systems, design of digital controllers, discrete PI-, PD-, and PID-controllers, compensation and dead-beat controller, anti-windup methods				
2	Learning objectives / Learning Outcomes The students know the fundamental analysis and design methods for digital feed-forward and feed-back control systems. They know the fundamental differences between continuous-time and discrete-time control systems and can design and analyze discrete-time control systems using different methods.				
3	Recommended prerequisite for participation Helpful is knowledge of the Laplace- and Fourier-transforms as well as continuous-time control systems. These fundamentals are taught in the lecture "System Dynamics and Control Systems I"				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module BSc/MSc Wi-ETiT, MSc ETiT, BSc/MSc CE, MSc MEC, BSc/MSc iST, MSc iCE, MSc Informatik				
7	Grade bonus compliant to §25 (2)				
8	References Lecture notes Konigorski: "Digitale Regelungssysteme" Ackermann: "Abtastregelung" Aström, Wittenmark: "Computer-controlled Systems" Föllinger: "Lineare Abtastsysteme" Phillips, Nagle: "Digital control systems analysis and design" Unbehauen: "Regelungstechnik 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme"				
Courses					
	Course Nr. 18-ko-2020-vl	Course name Digital Control Systems I			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Lecture	SWS 2
	Course Nr. 18-ko-2020-ue	Course name Digital Control Systems I			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Practice	SWS 1

Module name Identification of Dynamic Systems					
Module Nr. 18-ko-2040	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content <ul style="list-style-type: none"> • Introduction into the determination of mathematical process models based on measured data • Theoretical and experimental modeling of dynamic systems • System identification using continuous time signals: <ul style="list-style-type: none"> – Aperiodic signals <ul style="list-style-type: none"> * Fourier analysis * Evaluation of characteristic values (stepresponses) – Periodic signals <ul style="list-style-type: none"> * Frequency response analysis * Correlation analysis • System identification using discrete time signals: <ul style="list-style-type: none"> – Deterministic and stochastic signals – Basics in estimation theory – Correlation analysis • Parameter estimation techniques: <ul style="list-style-type: none"> – Least-squares estimation – Model structure determination – Recursive estimation algorithms • Kalman Filter and Extended Kalman Filter • Numerical Methods • Implementation under MatLab Numerous examples with real experimental data 				
2	Learning objectives / Learning Outcomes The students are taught the fundamental methods in signal and system analysis. Furthermore, the students master methods such as Fourier analysis, correlation analysis and parameter estimation methods. Based on this foundation, the students are able to assess and to apply the individual methods and can derive non-parametric as well as parametric models from measured data.				
3	Recommended prerequisite for participation MSc ETIT, MSc MEC				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module All disciplines of Electrical Engineering and Information Technology and similar disciplines (Mechatronics, Mechanical and Process Engineering, ...), Master of Science				
7	Grade bonus compliant to §25 (2)				
8	References				

Pintelon, R.; Schoukens, J.: System Identification: A Frequency Domain Approach. IEEE Press, New York, 2001.
 Ljung, L.: System Identification: Theory for the user. Prentice Hall information and systems sciences series. Prentice Hall PTR, Upper Saddle River NJ, 2. edition, 1999.

Courses

Course Nr. 18-ko-2040-vl	Course name Identification of Dynamic Systems		
Instructor Dr. Ing. Eric Lenz, M.Sc. Jonathan Hermann		Type Lecture	SWS 2
Course Nr. 18-ko-2040-ue	Course name Identification of Dynamic Systems		
Instructor Dr. Ing. Eric Lenz, M.Sc. Jonathan Hermann		Type Practice	SWS 1

Module name Modeling and Simulation					
Module Nr. 18-ko-2010	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content aim of modeling, theoretical modeling by application of fundamental physical laws, generalized network analysis, modeling of distributed parameter systems, model reduction, linearization, order reduction, digital simulation of linear systems, numerical integration methods				
2	Learning objectives / Learning Outcomes The students will know different techniques for the mathematical modeling of dynamic systems from various domains. They will acquire the ability to digitally simulate the dynamic behavior of the modeled systems and to systematically apply the available numerical integration methods.				
3	Recommended prerequisite for participation Basic knowledge of continuous- and discrete-time control theory. Supplementary lectures are "System Dynamics and Control Systems I and II" as well as "Digital Control Systems I and II".				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc MEC				
7	Grade bonus compliant to §25 (2)				
8	References Lecture notes Konigorski: "Modellbildung und Simulation", Lunze: „Regelungstechnik 1 und 2“, Föllinger: „Regelungstechnik: Einführung in die Methoden und ihre Anwendung“				
Courses					
	Course Nr. 18-ko-2010-vl	Course name Modeling and Simulation			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Lecture	SWS 2
	Course Nr. 18-ko-2010-ue	Course name Modeling and Simulation			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Practice	SWS 1

Module name Laboratory Control Engineering II					
Module Nr. 18-ad-2060	Credit Points 5 CP	Workload 150 h	Self study 90 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content During the laboratory course the following experiments will be conducted: Coupling control of a helicopter, Non-linear control of a gyroscope, Nonlinear multivariable control of an aircraft, Servo control systems, Control of an overhead crane system, Programmable logic control of a stirring process				
2	Learning objectives / Learning Outcomes After attending this laboratory course, a student is capable of: <ul style="list-style-type: none"> • recalling the basics of the conducted experiments, • organize and comprehend background information for experiments, • assemble experimental set-ups based on manuals, • judge the relevance of experimental results by comparing them with theoretically predicted outcomes, • present the results of the experiments 				
3	Recommended prerequisite for participation System Dynamics and Control Systems II, the attendance of the additional lecture “System Dynamics and Control Systems III” is recommended				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written Examination, Duration: 180 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Written Examination, Weighting: 100%) 				
6	Usability of this module MSc ETiT, MSc MEC, MSc iST, MSc Wi-ETiT, Biotechnik				
7	Grade bonus compliant to §25 (2)				
8	References Adamy: Instruction manuals for the experiments (available during the kick-off meeting)				
Courses					
	Course Nr. 18-ad-2060-pr	Course name Laboratory Control Engineering II			
	Instructor Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Jan Christian Zimmermann			Type Internship	SWS 4

2 Optional Modules

2.1 AUT I: Automatic Control Systems

Module name Digital Control Systems II					
Module Nr. 18-ko-2030	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content State space description of discrete-time systems, controllability, observability, state feedback controller, pole assignment, PI-state feedback controller, discrete state observers, modified Luenberger observer				
2	Learning objectives / Learning Outcomes The students know the state space description of sampled control systems and the corresponding analysis and design methods. They can design deadbeat controllers, state feedback controllers by pole assignment and PI- state feedback controllers for single input systems and know how to implement state feedback controllers together with a discrete- time observer.				
3	Recommended prerequisite for participation Knowledge of the z-transform as well as the fundamentals of discrete-time control systems. These fundamentals are taught in the lecture "Digital Control systems I".				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc Wi-ETiT, BSc/MSc iST, MSc MEC, MSc iCE				
7	Grade bonus compliant to §25 (2)				
8	References Lecture notes Konigorski: "Digitale Regelungssysteme" Ackermann: "Abtastregelung" Aström, Wittenmark: "Computer-controlled Systems" Föllinger: "Lineare Abtastsysteme" Phillips, Nagle: "Digital control systems analysis and design" Unbehauen: "Regelungstechnik 2: Zustandsregelungen, digitale und nichtlineare Regelsysteme"				
Courses					
	Course Nr. 18-ko-2030-vl	Course name Digital Control Systems II			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski			Type Lecture	SWS 1

	Course Nr. 18-ko-2030-ue	Course name Digital Control Systems II		
	Instructor Prof. Dr.-Ing. Ulrich Konigorski		Type Practice	SWS 1

Module name Fuzzy Logic, Neural Networks and Evolutionary Algorithms					
Module Nr. 18-ad-2020	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content Fuzzy systems: basics, rule based fuzzy logic, design methods, decision making, fuzzy control, pattern recognition, diagnosis; Neural networks: basics, multilayer perceptrons, radial basis functions, pattern recognition, identification, control, interpolation and approximation, Neuro-fuzzy: optimization of fuzzy systems, data driven rule generation; Evolutionary algorithms: optimization problems, evolutionary strategies and their applications, genetic programming and its applications				
2	Learning objectives / Learning Outcomes After attending the lecture, a student is capable of: <ul style="list-style-type: none"> • recalling the elements and set-up of standardized fuzzy-logic, neural networks and evolutionary algorithms, • discussing the pros and cons of certain set- ups of systems from computational intelligence for solving a given problem, • recognizing situations in which tools taken from computational intelligence can be applied for problem solving, • creating programs from algorithms taught in the lecture, and • extending the learned standard procedures in order to solve new problems. 				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100%) 				
6	Usability of this module BSc iST, MSc ETiT, MSc MEC, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik				
7	Grade bonus compliant to §25 (2)				
8	References Adamy: Fuzzy Logik, Neuronale Netze und Evolutionäre Algorithmen, Shaker Verlag (available for purchase at the FG office) www.rtr.tu-darmstadt.de (optionales Material)				
Courses					
	Course Nr. 18-ad-2020-vl	Course name Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms			
	Instructor Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Fabian Müller			Type Lecture	SWS 2
	Course Nr. 18-ad-2020-ue	Course name Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms			
	Instructor Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Fabian Müller			Type Practice	SWS 1

Module name Controller Design for Multivariable Systems in State Space					
Module Nr. 18-ko-2050	Credit Points 5 CP	Workload 150 h	Self study 90 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content Pole assignment, Coupling and decoupling of linear multivariable systems, Optimal control, Design of state observers, Dynamic state feedback control, Structurally constrained state feedback				
2	Learning objectives / Learning Outcomes The students will be able to analyse and design linear time-invariant multivariable systems by means of different state space design methods.				
3	Recommended prerequisite for participation Basic knowledge of linear control theory ("System Dynamics and Control Systems I and II")				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc MEC				
7	Grade bonus compliant to §25 (2)				
8	References Skript Konigorski: "Mehrgrößenregler im Zustandsraum", Anderson, Moore: "Optimal Control: Linear Quadratic Methods", Föllinger: "Regelungstechnik: Einführung in die Methoden und ihre Anwendung", Föllinger: "Optimale Regelung und Steuerung: Eine Einführung für Ingenieure", Roppenecker: "Zeitbereichsentwurf linearer Regelungen: Grundlegende Strukturen und eine Allgemeine Methodik ihrer Parametrierung", Unbehauen: "Regelungstechnik II: Zustandsregelungen, digitale und nichtlineare Regelungssysteme", Zurmühl: "Matrizen und ihre Anwendung: Für Angewandte Mathematiker, Physiker und Ingenieure. Teil 1: Grundlagen"				
Courses					
	Course Nr. 18-ko-2050-vl	Course name Controller Design for Multivariable Systems in State Space			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Viktor Kisner			Type Lecture	SWS 2
	Course Nr. 18-ko-2050-ue	Course name Controller Design for Multivariable Systems in State Space			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Viktor Kisner			Type Practice	SWS 2

Module name Industrial Electronics					
Module Nr. 18-ho-2210	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German and English			Module owner Prof. Dr.-Ing. Klaus Hofmann		
1	Content Typical Structure of Industrial Electronics Components. Characteristics of Typical Building Blocks (Digital Core, Sensor Frontend, Actuator Frontend, Supply and Reference Level), Functioning of Relevant Field Bus Systems, Knowledge of Relevant Standards and Technical Regulations.				
2	Learning objectives / Learning Outcomes After successful completion of the module, students are able to: 1. understand the use of electronic components in typical industrial environments, 2. understand the function of the building blocks of typical IE components, 3. deeply understand the functioning of analog building blocks, 4. understand relevant field bus systems, 5. understand the regulatory and technical standards of industrial electronics components.				
3	Recommended prerequisite for participation Lecture "Elektronik" and "Analog IC Design"				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, M.Sc. iCE, M.Sc. MEC				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> Dietmar Schmid, Gregor Häberle, Bernd Schiemann, Werner Philipp, Bernhard Grimm, Günther Buchholz, Jörg Oestreich, Oliver Gomber, Albrecht Schilling: „Fachkunde Industrieelektronik und Informationstechnik“; Verlag Europa-Lehrmittel, 11 th Ed. 2013. Gunter Wellenreuther, Dieter Zastrow; „Automatisieren mit SPS – Theorie und Praxis“; Springer Verlag, 6 th Ed. 2015. Ulrich Tietze, Christoph Schenk, Eberhard Gamm: „Halbleiter-Schaltungstechnik“; Springer Verlag, 15 th Ed. 2016. 				
Courses					
	Course Nr. 18-ho-2210-vl	Course name			
	Instructor Dr.-Ing. Roland Steck			Type Lecture	SWS 2
	Course Nr. 18-ho-2210-ue	Course name			
	Instructor Dr.-Ing. Roland Steck			Type Practice	SWS 1

2.2 AUT II: Information Technology - Practical courses, seminars, project seminars

Module name Computer Vision in Engineering					
Module Nr. 18-ad-2090	Credit Points 4 CP	Workload 120 h	Self study 75 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content A Basics <ul style="list-style-type: none"> • Scene Representation 2D and 3D Geometry • Image Acquisition <ul style="list-style-type: none"> – Geometric Projections Camera Calibration • Objective and Illumination • Discrete 2D signals <ul style="list-style-type: none"> – Separability, Sampling – Transformation, Interpolation – Convolution, Correlation – Discrete Fourier Transformation B Basics of Image Analysis <ul style="list-style-type: none"> • Filtering <ul style="list-style-type: none"> – Basics 2D Filter Design – Linear Filtering – Nonlinear Filtering • Image Decompositions <ul style="list-style-type: none"> – Multi-scale Representation – Pyramids – Filter Banks • Image Features <ul style="list-style-type: none"> – Structure – Moments, Histograms 				
2	Learning objectives / Learning Outcomes The lecture communicates mathematical basics needed to solve computer vision problems in the field of engineering. The focus is on methods that are relevant for measuring and control tasks. Applications range from visual quality inspection, visual robotics, photogrammetry, visual odometry up to visually guided driver assistance etc. The students should obtain a good understanding for the relations between the three-dimensional world and its two-dimensional projection onto the image plane of a camera. They also should learn about methods that exist to infer knowledge from the world given image data. They should develop some feeling for the different kinds of problems that arise in computer vision and how to choose an efficient solution in terms of algorithms.				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading				

	Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 		
6	Usability of this module MSc ETiT, MSc iST, MSc CE, MSc iST		
7	Grade bonus compliant to §25 (2)		
8	References References / Textbooks: Lecture slides, exercise sheets and matlab-code. Further reading <ul style="list-style-type: none"> • Yi Ma, Stefano Soatto, Jana Kosecka und Shankar S. Sastry, An Invitation to 3-D Vision - From Images to Geometric Models, Springer, 2003. • Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004. • Karl Kraus, Photogrammetrie, Band 1 Geometrische Informationen aus Photographien und Laser-scanneraufnahmen 7. Auflage, de Gruyter Lehrbuch, 2004. • Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006. • Bernd Jähne, Digital Image Processing, 6. Auflage, 2005. 		
Courses			
	Course Nr. 18-ad-2090-vl	Course name Computer Vision in Engineering	
	Instructor Dr.-Ing. Volker Willert, Prof. Dr.-Ing. Jürgen Adamy		Type Lecture
			SWS 2
	Course Nr. 18-ad-2090-ue	Course name Computer Vision in Engineering	
	Instructor Dr.-Ing. Volker Willert		Type Practice
			SWS 1

Module name Power Electronics					
Module Nr. 18-gt-1010	Credit Points 5 CP	Workload 150 h	Self study 90 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Gerd Griepentrog		
1	Content Power electronic devices convert the energy from the distribution network to the form required by the load. This conversion does not wear out, can be controlled very fast and has a high efficiency. In lecture "Power Electronics" the most important circuits required for the energy conversion are treated, using ideal switches. The main chapters are I.) Line commutated converters in order to understand the basic concepts of power electronic systems. II.) Self- commutated converters (one, two and four quadrant converters, 3-phase- VSI)				
2	Learning objectives / Learning Outcomes After an active participation in the lecture, as well as by solving all exercises prior to the respective tutorial students should be able to: <ul style="list-style-type: none"> • Understand the ideal concept of power semiconductors • Calculate and sketch the time-characteristics of all currents and voltages in a line-commutated converter using defined simplifications as well as represent the behavior of currents and voltages during commutation in line-commutated converters for center –tapped as well as for bridge circuits. • Specify the basic circuit diagrams for one, two and four quadrant DC/DC converters and calculate the characteristics of voltages and currents in these circuits. • Explain the function of single-phase and three-phase voltage source inverters and calculate the currents and voltages in these circuits using defined simplifications. • Understand the concept and operation of HVDC transmission 				
3	Recommended prerequisite for participation Mathe I und II, ETiT I und II, Energietechnik				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written Examination, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc MEC, Wi-ETiT				
7	Grade bonus compliant to §25 (2)				
8	References Lecture notes, instructions for exercises are available for download in Moodle. Literature: Probst U.: „Leistungselektronik für Bachelors: Grundlagen und praktische Anwendungen“, Carl Hanser Verlag GmbH & Co. KG, 2011 Jäger, R.: „Leistungselektronik: Grundlagen und Anwendungen“, VDE-Verlag; Auflage 2011 Heumann, K.: „Grundlagen der Leistungselektronik“; Teubner; Stuttgart; 1985 Lappe, R.: „Leistungselektronik“; Springer-Verlag; 1988 Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design; John Wiley Verlag; New York; 2003				

Courses			
	Course Nr. 18-gt-1010-vl	Course name Power Electronics	
	Instructor Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Milad Khani		Type Lecture
			SWS 2
	Course Nr. 18-gt-1010-ue	Course name Power Electronics	
	Instructor Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Milad Khani		Type Practice
			SWS 2

Module name Materials of Electrical Engineering					
Module Nr. 11-01-6410	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered Every 2. Sem.
Language German			Module owner Prof. Dr. rer. nat. Lambert Alff		
1	Content				
2	Learning objectives / Learning Outcomes				
3	Recommended prerequisite for participation				
4	Form of examination Module Ecompanying Examination: • [11-01-6410-vl] (Technical Examination, Technical Examination, Standard BWS)				
5	Grading Module Ecompanying Examination: • [11-01-6410-vl] (Technical Examination, Technical Examination, Weighting: 100 %)				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References				
Courses					
	Course Nr. 11-01-6410-vl	Course name Materials of Electrical Engineering			
	Instructor			Type Lecture	SWS 2

Module name Numerical Methods for Ordinary Differential Equations for Engineers					
Module Nr. 04-10-0042/de	Credit Points 5 CP	Workload 150 h	Self study 105 h	Duration 1	Cycle offered Every 2. Sem.
Language German			Module owner Prof. Dr. techn. Herbert Egger		
1	Content initial value problems: one-step methods, multi-step methods; convergence analysis, notions of stability; boundary-value problems: Shooting methods, finite difference methods, stability and convergence;				
2	Learning objectives / Learning Outcomes Students know the basic numerical solution concepts for ordinary differential equations and they are able to analyze, compare, and apply them.				
3	Recommended prerequisite for participation recommended: Analysis, Linear Algebra, Ordinary Differential Equations, Introduction to Numerical Analysis or similar knowledge as taught in an engineering programme.				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) • Module Examination (Study Achievement, Special Form, Pass/Fail Grading System) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Weighting: 100 %) • Module Examination (Study Achievement, Special Form, Weighting: 0 %) 				
6	Usability of this module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics				
7	Grade bonus compliant to §25 (2)				
8	References Deuffhard, Bornemann: Numerische Mathematik 2 Stoer, Bulirsch: Numerische Mathematik 2				
Courses					
	Course Nr. 04-10-0134-vu	Course name			
	Instructor Prof. Dr. techn. Herbert Egger			Type Lecture & Practice	SWS 3

Module name Numerical Linear Algebra					
Module Nr. 04-10-0043/de	Credit Points 5 CP	Workload 150 h	Self study 105 h	Duration 1	Cycle offered Every 2. Sem.
Language German			Module owner Dr. rer. nat. Alf Gerisch		
1	Content Systems of linear equations: iterative methods, singular value decomposition, eigenvalue problems.				
2	Learning objectives / Learning Outcomes Students know about the most important numerical methods of linear algebra and they are able to explain, classify, and apply them.				
3	Recommended prerequisite for participation recommended: Linear Algebra, Introduction to Numerical Analysis or similar knowledge				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) • Module Examination (Study Achievement, Special Form, Pass/Fail Grading System) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Weighting: 100 %) • Module Examination (Study Achievement, Special Form, Weighting: 0 %) 				
6	Usability of this module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics				
7	Grade bonus compliant to §25 (2)				
8	References Trefethen/Bau: Numerical Linear Algebra, SIAM Demmel: Applied Numerical Linear Algebra, SIAM Stoer/Bulirsch: Numerische Mathematik 2, Springer				
Courses					
	Course Nr. 04-00-0139-vu	Course name Numerical Linear Algebra			
	Instructor Dr. rer. nat. Alf Gerisch			Type Lecture & Practice	SWS 3

Module name Laboratory Matlab/Simulink II					
Module Nr. 18-ko-2070	Credit Points 4 CP	Workload 120 h	Self study 60 h	Duration 1	Cycle offered WiSe/SoSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content The lab is split into the two parts Simulink and Control Engineering II. First the fundamentals of the simulation tool Simulink are introduced and their application to problems from different fields of application is trained. In the second part, the knowledge gained in the first part is applied to autonomously solve several control design problems as well as simulation tasks.				
2	Learning objectives / Learning Outcomes The students will be able to work with the tool MatLab/Simulink on their own and can solve tasks from the areas of control engineering and numerical simulation. The students will know the different design methods of the control system toolbox and the fundamental concepts of the simulation tool Simulink. They can practically apply the knowledge gathered in the lectures “System Dynamics and Control Systems I and II” and “Modelling and Simulation”.				
3	Recommended prerequisite for participation The lab should be attended in parallel or after the lectures “System Dynamics and Control Systems II” and “Modelling and Simulation”				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSC MEC				
7	Grade bonus compliant to §25 (2)				
8	References Lecture notes for the lab tutorial can be obtained at the secretariat				
Courses					
	Course Nr. 18-ko-2070-pr	Course name Laboratory Matlab/Simulink II			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Marcel Bonnert			Type Internship	SWS 4

Module name Project Seminar Automatic Control Systems					
Module Nr. 18-ad-2080	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content The students work in small groups, supervised by a scientific staff member, on individual problems taken from the field of automatic control. A compulsory training course is part of the project course and will cover the topics 1. team work and project management, 2. professional presentation skills, and 3. scientific writing skills.				
2	Learning objectives / Learning Outcomes After attending the project course, a student is capable of: 1. planing a small project, 2. organizing the work within a project team, 3. searching for scientific background information on a given project, 4. creating ideas on how to solve problems arising in the project, 5. presenting the results in a scientific report, and 6. giving a talk on the results of the project.				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik				
7	Grade bonus compliant to §25 (2)				
8	References Training course material				
Courses					
	Course Nr. 18-ad-2080-pj	Course name Project Seminar Automatic Control Systems			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Project Seminar	SWS 4

Module name Project Course Practical Application of Mechatronics					
Module Nr. 18-ko-2130	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content Teams of 2-4 students work on different mechatronic projects under the guidance of a project coordinator from the institute. The projects mainly cover the following subject areas: <ul style="list-style-type: none"> • Modeling, analysis, and design of mechatronic systems • Robust control design • System analysis, supervision and fault diagnosis • Modeling and identification Application areas are mechatronic actuators, machine tools, production lines, test benches, automobiles, quadcopters.				
2	Learning objectives / Learning Outcomes After completing the project, the students will be familiar with the individual steps of investigating a mechatronic project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate mechatronic solutions and their real technical implementation. Doing so, the students learn the practical application of mechatronic methods taught in the lectures to real world problems. Additionally, in this project course, the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.				
3	Recommended prerequisite for participation Lectures „System Dynamics and Automatic Control Systems I“, „System Dynamics and Automatic Control Systems II“				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc MEC, MSc iST				
7	Grade bonus compliant to §25 (2)				
8	References Handouts will be distributed at start of the project (e.g. hints for writing project documentation, etc.)				
Courses					
	Course Nr. 18-ko-2130-pj	Course name Project Course Practical Application of Mechatronics			
	Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Julian Zeiß			Type Project Seminar	SWS 4

Module name Project Course Control Engineering					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-ko-2090	8 CP	240 h	180 h	1	SoSe
Language			Module owner		
German			Prof. Dr.-Ing. Ulrich Konigorski		
1	Content Teams of 2 - 4 students work on different control engineering projects under the guidance of a project coordinator from the institute. The projects mainly cover the following subject areas: <ul style="list-style-type: none"> • Modelling, analysis and design of multivariable control systems • Modelling, analysis and design of distributed parameter systems • Robust control design • System analysis, supervision and fault diagnosis • Modelling and identification Application areas are machine tools, production lines, test benches, process control, automobiles.				
2	Learning objectives / Learning Outcomes After completing the project the students will be familiar with the individual steps of investigating a control engineering project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate control engineering solutions and their real technical implementation. Doing so the students learn the practical application of control engineering methods taught in the lecture "System Dynamics and Control Systems I" to real world problems. Additionally, in this project course the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.				
3	Recommended prerequisite for participation Lecture "System Dynamics and Control Systems I"				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Optional, Weighting: 100%) 				
6	Usability of this module MSc ETiT, MSc MEC				
7	Grade bonus compliant to §25 (2)				
8	References Handouts will be distributed at start of the project (e.g. Hints for writing a project documentation, etc.)				
Courses					
	Course Nr.	Course name			
	18-ko-2090-pj	Project Course Control Engineering			
	Instructor			Type	SWS
	Prof. Dr.-Ing. Ulrich Konigorski			Project Seminar	4

Module name Project Seminar Robotics and Computational Intelligence					
Module Nr. 18-ad-2070	Credit Points 8 CP	Workload 240 h	Self study 180 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content The following topics are taught in the lecture: 1. Industrial robots, 1a. Types and applications, 1b. Geometry and kinematics, 1c. Dynamic model, 1d. Control of industrial robots, 2. Mobile robots, 2a. Types and applications, 2b. Sensors, 2c. Environmental maps and map building, 2d. Trajectory planning. Group projects are arranged after the lectures in order to apply the taught material in practical exercises.				
2	Learning objectives / Learning Outcomes After attending the lecture, a student is capable of: 1. recalling the basis elements of industrial robots, 2. recalling the dynamic equations of industrial robots and be able to apply them to describe the dynamics of a given robot, 3. stating model problems and solutions to standard problems in mobile robotics, 4. planing a small project, 5. organizing the work load in a project team, 6. searching for additional background information on a given project, 7. creating ideas on how to solve problems arising in the project, 8. writing an scientific report about the outcome of the project 8. presenting the results of the project.				
3	Recommended prerequisite for participation				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Study Achievement, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik				
7	Grade bonus compliant to §25 (2)				
8	References Adamy: Lecture notes (available for purchase at the FG office)				
Courses					
	Course Nr. 18-ad-2070-pj	Course name Project Seminar Robotics and Computational Intelligence			
	Instructor Prof. Dr.-Ing. Jürgen Adamy			Type Project Seminar	SWS 4

Module name Computer Systems I					
Module Nr. 18-hb-1020	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Christian Hochberger		
1	Content Types of instruction sets, memory organization and its impact on the runtime, pipelining, instruction level parallelism, superscalar processors, VLIW processors, floating point numbers and operations, memory subsystem, cache types, virtual address spaces, benchmarking and performance prediction, system architecture and bus systems, peripheral devices				
2	Learning objectives / Learning Outcomes Successful students can analyze and evaluate processors, memory systems and bus systems. They can transform structures of high-level programming languages like subroutine calls into sequences of machine instructions. They are able to measure the performance of computers. They know how instructions are executed in modern processors and thus, they can predict the influence of a specific memory hierarchy onto the execution time of a given program. They know how internal and external bus systems work and can define the essential parameters for their dimension and operation.				
3	Recommended prerequisite for participation Basic knowledge of digital design as it can be obtained by the lecture "Logic Design".				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Written Examination, Weighting: 100%) 				
6	Usability of this module BSc ETiT, BSc Wi-ETiT				
7	Grade bonus compliant to §25 (2)				
8	References Hennessy/Patterson: Computer architecture - a quantitative approach				
Courses					
	Course Nr. 18-hb-1020-vl	Course name Computer Systems I			
	Instructor Prof. Dr.-Ing. Christian Hochberger			Type Lecture	SWS 3
	Course Nr. 18-hb-1020-ue	Course name Computer Systems I			
	Instructor Prof. Dr.-Ing. Christian Hochberger			Type Practice	SWS 1

Module name Autonomous Driving Lab I					
Module Nr. 18-su-2070	Credit Points 6 CP	Workload 180 h	Self study 135 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr. rer. nat. Andreas Schürr		
1	Content <ul style="list-style-type: none"> • Hands-on programming experience with C++ in the development of embedded software systems for autonomous driving based on a model car • Application of control methods from the area of autonomous driving • Application of software engineering techniques (design, documentation, test, ...) of a non-trivial embedded software system with hard real-time requirements and limited resources (memory, ...) • Use of a given software framework and further libraries including a modular (real-time) operating system • Hands-on experience using source code management systems, time management and other project management tools • Presentations of the project results 				
2	Learning objectives / Learning Outcomes During this project seminar students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems). Students that have successfully participated in this project seminar are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail: <ul style="list-style-type: none"> • Independent familiarization with a given software framework and ready-made libraries • Transfer of theoretic knowledge into a software system • Extensive use of tools for version, configuration, and change management • Realistic time and resource management (project management) • Development of hardware/software systems with C++ considering important limitations of embedded systems • Planning and implementation of extensive quality assurance measures • Collaboration and communication in and between teams 				
3	Recommended prerequisite for participation Recommended prerequisites are: <ul style="list-style-type: none"> • ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++) Additionally desired: <ul style="list-style-type: none"> • Basic knowledge of the development of real-time systems or image processing • ETiT/AUT, MEC: Basic knowledge in control engineering including state space control design, some additional basic knowledge in digital control design may be helpful 				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) 				
5	Grading				

	Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)		
6	Usability of this module MSc ETiT, BSc iST		
7	Grade bonus compliant to §25 (2)		
8	References https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-i/ and Moodle		
Courses			
	Course Nr. 18-su-2070-pj	Course name Autonomous Driving Lab I	
	Instructor Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz, M.Sc. Stefan Tomaszek	Type Project Seminar	SWS 3

Module name Robust Control					
Module Nr. 18-ko-2140	Credit Points 3 CP	Workload 90 h	Self study 60 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Ulrich Konigorski		
1	Content <ul style="list-style-type: none"> • Basics (SVD, norms, system representations) • Control design in the frequency domain <ul style="list-style-type: none"> – Expressing control tasks as H2 and Hinf optimization problems – Design of H2 and Hinf optimal controllers • Robust Control <ul style="list-style-type: none"> – Uncertainty representations (Additive und multiplicative uncertainties, multi model representations) – Analysis of robustness (Small-Gain-theorem, mu-analysis) – Robust control design in the frequency domain Robust control design by region-based pole placement 				
2	Learning objectives / Learning Outcomes The students are able to express control tasks as H2 and H8 optimization problems, to represent uncertainties of a system in a suitable form and to design a controller which ensures robust stability and robust performance.				
3	Recommended prerequisite for participation Systemdynamik und Regelungstechnik I und II				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module MSc ETiT, MSc MEC				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> • S. Skogestad, I. Postlethwaite, Multivariable Feedback Control, 2. Auflage, 2005, Wiley • K. Zhou, Essentials of Robust Control, 1998, Prentice-Hall • O. Föllinger, Regelungstechnik, 11. Auflage, 2013, VDE Verlag 				
Courses					
	Course Nr. 18-ko-2140-vl	Course name Robust Control			
	Instructor Dr. Ing. Eric Lenz			Type Lecture	SWS 2

Module name Matrix Analysis and Computations					
Module Nr. 18-pe-2070	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language English			Module owner Prof. Dr.-Ing. Marius Pesavento		
1	Content This graduate course is a foundation class on matrix analysis and computations, which are widely used in many different fields, e.g., machine learning, computer vision, systems and control, signal and image processing, communications, networks, optimization, and many more. . . Apart from the theory this course will also cover the design of efficient algorithm and it considers many different examples from the aforementioned fields including examples from social media and big data analysis, image processing and medical imaging, communication network optimization, and written text classification. Specific topics: (i) basic matrix concepts, subspace, norms, (ii) linear least squares (iii) eigendecomposition, singular value decomposition, positive semidefinite matrices, (iv) linear system of equations, LU decomposition, Cholesky decomposition (v) pseudo-inverse, QR decomposition (vi) advanced tensor decomposition, advanced matrix calculus, compressive sensing, structured matrix factorization				
2	Learning objectives / Learning Outcomes Students will learn matrix analysis and computations at an advanced or research level.				
3	Recommended prerequisite for participation Basic knowledge in linear algebra.				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Standard Grading System) 				
5	Grading Module Final Examination: <ul style="list-style-type: none"> Module Examination (Technical Examination, Optional, Weighting: 100 %) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References 1.Gene H. Golub and Charles F. van Loan, Matrix Computations (Fourth Edition), John Hopkins University Press, 2013. 2.Roger A. Horn and Charles R. Johnson, Matrix Analysis (Second Edition), Cambridge University Press, 2012. 3.Jan R. Magnus and Heinz Neudecker, Matrix Differential Calculus with Applications in Statistics and Econometrics (Third Edition), John Wiley and Sons, New York, 2007. 4.Giuseppe Calaore and Laurent El Ghaoui, Optimization Models, Cambridge University Press, 2014. ECE 712 Course Notes by Prof. Jim Reilly, McMaster University, Canada (friendly notes for engineers) http://www.ece.mcmaster.ca/faculty/reilly/ece712/course_notes.htm				
Courses					
	Course Nr. 18-pe-2070-vl	Course name Matrix Analysis and Computations			
	Instructor Prof. Dr.-Ing. Marius Pesavento			Type Lecture	SWS 3

	Course Nr. 18-pe-2070-ue	Course name Matrix Analysis and Computations		
	Instructor Prof. Dr.-Ing. Marius Pesavento		Type Practice	SWS 1

Module name Machine Learning and Deep Learning for Automation Systems					
Module Nr.	Credit Points	Workload	Self study	Duration	Cycle offered
18-ad-2100	3 CP	90 h	60 h	1	SoSe
Language German			Module owner Prof. Dr.-Ing. Jürgen Adamy		
1	Content <ul style="list-style-type: none"> • Concepts of machine learning • Linear methods • Support vector machines • Trees and ensembles • Training and assessment • Unsupervised learning • Neural networks and deep learning • Convolutional neuronal networks (CNNs) • CNN applications • Recurrent neural networks (RNNs) 				
2	Learning objectives / Learning Outcomes Students will get a broad and practical view on the field of machine learning. First, the most relevant algorithm classes of supervised and unsupervised learning are discussed. After that, the course addresses deep neural networks, which enable many of today's applications in image and signal processing. The fundamental characteristics of all algorithms are compiled and demonstrated by programming examples. Students will be able to assess the methods and apply them to practical tasks.				
3	Recommended prerequisite for participation Fundamental knowledge in linear algebra and statistics Preferred: Lecture "Fuzzy logic, neural networks and evolutionary algorithms"				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 7 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100%) 				
6	Usability of this module				
7	Grade bonus compliant to §25 (2)				
8	References <ul style="list-style-type: none"> • T. Hastie et al.: The Elements of Statistical Learning. 2. Aufl., Springer, 2008 • I. Goodfellow et al.: Deep Learning. MIT Press, 2016 • A. Géron: Hands-On Machine Learning with Scikit-Learn and TensorFlow. O'Reilly, 2017 				
Courses					

	Course Nr. 18-ad-2100-vl	Course name Machine Learning and Deep Learning for Automation Systems		
	Instructor Dr.-Ing. Michael Vogt		Type Lecture	SWS 2

2.3 AUT III: Thermodynamics and Fluid Dynamics

Module name Fundamental Fluid Mechanics					
Module Nr. 16-11-5010	Credit Points 6 CP	Workload 180 h	Self study 120 h	Duration 1	Cycle offered SoSe
Language German			Module owner Prof. Dr.-Ing. Cameron Tropea		
1	Content Properties of fluids, flow kinematics, conservation equations, constitutive equations, equations of motion, Navier-Stokes equations, hydrostatics, exact solutions, turbulent flows, stream filament theory, flow around bodies.				
2	Learning objectives / Learning Outcomes On successful completion of this module, students should be able to: <ul style="list-style-type: none"> • Explain the origins and limitations of the basic conservation equations of fluid mechanics (mass, momentum, moment of momentum, energy). • Choose the correct equations, simplifications, and boundary conditions for a given application and recognise avenues for solution. • Use stream filament theory and loss coefficients to compute flow networks. These capabilities are developed for incompressible, single phase flows. 				
3	Recommended prerequisite for participation knowledge of ordinary and partial differential equations				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Written exam 2x 150 min				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Weighting: 100 %) 				
6	Usability of this module Bachelor MPE Pflicht Master ETiT AUT; Bachelor Mechatronik				
7	Grade bonus compliant to §25 (2)				
8	References Spurk: Strömungslehre, Springer Verlag. Spurk: Aufgaben zur Strömungslehre, Springer Verlag.				
Courses					
	Course Nr. 16-11-5010-vl	Course name Fundamental Fluid Mechanics			
	Instructor			Type Lecture	SWS 3
	Course Nr. 16-11-5010-ue	Course name Fundamental Fluid Mechanics			
	Instructor			Type Practice	SWS 1

Module name Technical Thermodynamics I					
Module Nr. 16-14-5010	Credit Points 6 CP	Workload 180 h	Self study 105 h	Duration 1	Cycle offered WiSe
Language German			Module owner Prof. Dr.-Ing. Peter Christian Stephan		
1	Content Fundamental terms of thermodynamics; thermodynamic equilibrium and temperature; different forms of energy (internal energy, heat, work, enthalpy); properties and equations of state for gases and incompressible substances; first law of thermodynamics and energy balances for technical systems; second law of thermodynamics and entropy balances for technical systems; exergy analysis; thermodynamic behaviour during phase change; the carnot cycle for power generation or refrigeration; energy efficiency and coefficient of performance; cyclic processes for gas turbines, combustion engines, power plants, refrigerators and heat pumps.				
2	Learning objectives / Learning Outcomes On successful completion of this module, students should be able to: <ul style="list-style-type: none"> • Explain the relationships between thermodynamic properties and the thermodynamic state of a system and apply them within calculations of thermal system behaviour. • Distinguish between different types of energy (e.g. work, heat, internal energy, enthalpy) and define them. • Analyse technical systems and processes using energy balances and equations of state. • Assess energy conversion processes by means of an entropy balance or an exergy analysis. • Characterise the thermal behaviour of gases, liquids and solids and corresponding phase change processes. • Apply this basic knowledge (1.-5.) to examine machines (turbines, pumps etc.) and processes for energy conversion (combustion engine, power plants, refrigerators, heat pumps). 				
3	Recommended prerequisite for participation None				
4	Form of examination Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Written exam 150 min				
5	Grading Module Final Examination: <ul style="list-style-type: none"> • Module Examination (Technical Examination, Technical Examination, Weighting: 100 %) 				
6	Usability of this module Bachelor MPE Pflicht Bachelor WI-MB Master ETiT MFT, Bachelor Mechatronik				
7	Grade bonus compliant to §25 (2)				
8	References P Stephan; K. Schaber; K. Stephan; F. Mayinger: Thermodynamik, Band 1: Einstoffsysteme, Springer Verlag. Further material (slides, collection of exercises, table of formulas etc.) is available through the Moodle system of TU Darmstadt.				
Courses					

	Course Nr. 16-14-5010-vl	Course name Technical Thermodynamics I		
	Instructor		Type Lecture	SWS 3
	Course Nr. 16-14-5010-hü	Course name Technical Thermodynamics I		
	Instructor		Type Lecture Hall Practice	SWS 1
	Course Nr. 16-14-5010-gü	Course name Technical Thermodynamics I - Group Exercise		
	Instructor		Type Group Practice	SWS 1