Antrag auf Akkreditierung von Studiengängen

Master-Studiengang Mechatronics

Getragen von den Fachbereichen 12 “Elektrotechnik und Informatik“
und 11 “Maschinenbau“ der Universität Siegen

Anhang B

Modulhandbuch

(V1.0 – 01.03.06)

Title	**Embedded Control**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS ; exercises/laboratory (Programming/Simulation) : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Hubert Roth M.Sc. Asif Iqbal
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	1) Fundamentals of Control Theory 2) Electronics, Basic Digital Electronics 3) Programming Languages 4) Modeling and Simulation
Contents	Lectures: 1) What are embedded control systems 2) Concepts of creating and applying embedded control systems 3) Basic components of embedded control systems 3.1) Hardware Aspects: Microcontrollers, I/O components, distributed systems,field busses,... 3.2) Software Aspects: real-time operating systems, events and determinism, scheduling policies... 4) Numerical Simulations: mathematical descriptions of dynamic systems, numerical data formats, numerical errors, solving differential equations,... 5) Real-Time Simulations: Running numerical calculations in real-time; coordinating real-time OS, Input-Output components and numerical calculations 6) Using state-of-the-art-tools for embedded controller development: dSPACE Prototyper and MATLAB/Simulink Tutorial/Labs: The tutorial accompanies the lectures and will teach you to use the quasi-standard simulation environment MATLAB/Simulink of The MathWorks. You will have to solve small exercises and the results have to be presented in the group. The course finishes with a real world experiment where a controller has to be designed for a classical inverse pendulum using a dSPACE RCP environment.
Learning objectives	The Purposes of the course are to - become acquainted with application fields of embedded control systems - understand working methods to develop embedded control systems - get to know motivations of Rapid Control

	Prototyping (RCP), hardware-in-the-loop (HIL) and Calibration - work with state-of-the-art development tools for real-time simulation and rapid control prototyping (as MATLAB/Simulink and the dSPACE Prototyper) - provide enough background knowledge (numerical mathematics, operating systems, system theory) to even understand the functionality of these development tools. - finally bridge the gap from theory to practical implementing by performing a practical experiment in the lab.
Recommended literature	Stallings, W.: Operating Systems (Internals and Design Principles).
Examination	K2 (written exam, 2 hours)

Title	**Electrical and Electronic Engineering I**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture/exercises : 4 SWS
Professor in charge Lecturer	Dr.-Ing. Klaus Teichmann
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	
Contents	**Electromagnetic Fields** Electric Forces and Electric Fields Magnetic Forces and Magnetic Fields Electrodynamics **Basic Circuit Theory** Energy and Charge Current and Kirchhoff's Current Law Voltage and Kirchhoff's Voltage Law Energy Flow in Electrical Circuits Circuit Elements: Resistances and Sources Series and Parallel Resistances: Voltage and Current Dividers **The Analysis of DC Circuits** Superposition Thevenin's and Norton's Equivalent Circuits Source Transformations Node-Voltage Analysis Loop-Current Analysis, **The Dynamics of Circuits** Theory of Inductors and Capacitors First-Order Transient Response of RL and RC-Circuits RLC Circuits **The Analysis of AC Circuits** Introduction to Alternating Current (AC) AC Circuit Problem Representing Sinusoids with Phasors, Impedance: Representing the Circuit in the Frequency Domain Phasor Diagrams for RL, RC, and RLC-Circuits **Power in AC Circuits** AC Power and Energy in the Time-Domain Power and Energy in the Frequency Domain Transformers Polyphase Systems

Learning objectives	The course is provided for students who previously studied Mechanical Engineering. During the course the students learn fundamentals of Electrical and Electronic Engineering. This knowledge is required for understanding advanced topics in higher semester courses. The topic of the first part of the course is basic circuit theory including various methods for circuit analysis. In the second part of the course this base knowledge is applied to analyze analog electronic circuits. The third part of the course covers digital electronics focusing on methods for the synthesis of combinatorial and sequential circuits. In the final part of the course some fundamentals on electromagnetic fields are taught. They provide base knowledge for understanding electrical machines and other electromagnetic systems. Various exercises are provided in each part of the course. These exercises should be solved at home. The solutions are discussed during the class hours.
Recommended literature	Foundations of electrical engineering - J. R. Cogdell - Prentice Hall Introduction to Electrical Engineering - M.S. Sarma - Oxford University Press Electric Circuits (5th edition) - Nilsson and Riedel - Addison Wesley Schaum's Outline of Basic Electrical Engineering - J.J. Cathey - McGraw-Hill Professional Publishing Introduction to Electric Circuits (4th edition) - Dorf & Svoboda, - John Wiley and Sons Electric Circuit Analysis - Ken Sander - Addison Wesley Basic Engineering Circuit Analysis (5th edition) - J David Irvin - Prentice Hall Electrical and Electronic Technology (8th edition) - E. Hughes - Prentice Hall Linear Circuit Analysis (2nd Edition) - DeCarlo/Lin - Oxford University Press Fundamentals of Electrical Engineering - L.S. Bobrow, - Oxford University Press Electrical and electronics engineering for scientists and engineers - K. A. Krishnamurthy, M.R. Raghuveer - John Wiley and Sons
Examination	K2 (written exam, 2 hours)

Title	**Electrical and Electronic Engineering II**
Credit points	2,5
Module elements (Lecture/exercises/lab)	Lecture/exercises : 2 SWS
Professor in charge Lecturer	Dr.-Ing. Klaus Teichmann
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	
Contents	**Semiconductor Diodes** Circuit Analysis for an Ideal Diode The pn-Junction Diode Equivalent Circuits for Nonideal Diodes **Semiconductor Transistors** Bipolar-Junction-Transistor (BJT) Junction Field-Effect Transistors Metal-Oxide Semiconductor Field-Effect-Transistors (MOSFETs) **Semiconductor Circuits** Transistor Amplifier-Switch Circuit Analysis Transistor Applications Small-Signal Amplifiers **Analog Electronics** Electrical Filters Feedback Concepts Transistor Circuits Operational-Amplifier Circuits Basic Op-Amp Amplifiers Linear Op-Amp Circuits Nonlinear Op-Amp Circuits Instrumentation Amplifiers Analog Active Filters **Digital Electronics** Digital Information The Electronics of Digital Signals The Mathematics of Digital Electronics (Boolean Algebra) **Combinational Digital Systems** Binary Arithmetic Digital Arithmetic Circuits Karnaugh Maps **Sequential Digital Systems** Bistable Circuit Latches and Flip-Flops Flip-Flop Applications

Learning objectives	The course is provided for students who previously studied Mechanical Engineering. During the course the students learn fundamentals of Electrical and Electronic Engineering. This knowledge is required for understanding advanced topics in higher semester courses. The topic of the first part of the course is basic circuit theory including various methods for circuit analysis. In the second part of the course this base knowledge is applied to analyze analog electronic circuits. The third part of the course covers digital electronics focusing on methods for the synthesis of combinatorial and sequential circuits. In the final part of the course some fundamentals on electromagnetic fields are taught. They provide base knowledge for understanding electrical machines and other electromagnetic systems. Various exercises are provided in each part of the course. These exercises should be solved at home. The solutions are discussed during the class hours.
Recommended literature	Foundations of electrical engineering - J. R. Cogdell - Prentice Hall Introduction to Electrical Engineering - M.S. Sarma - Oxford University Press Electric Circuits (5th edition) - Nilsson and Riedel - Addison Wesley Schaum's Outline of Basic Electrical Engineering - J.J. Cathey - McGraw-Hill Professional Publishing Introduction to Electric Circuits (4th edition) - Dorf & Svoboda, - John Wiley and Sons Electric Circuit Analysis - Ken Sander - Addison Wesley Basic Engineering Circuit Analysis (5th edition) - J David Irvin - Prentice Hall Electrical and Electronic Technology (8th edition) - E. Hughes - Prentice Hall Linear Circuit Analysis (2nd Edition) - DeCarlo/Lin - Oxford University Press Fundamentals of Electrical Engineering - L.S. Bobrow, - Oxford University Press Electrical and electronics engineering for scientists and engineers - K. A. Krishnamurthy, M.R. Raghuveer - John Wiley and Sons

Examination	K1 (written exam, 1 hour)

Title	**Materials Science and Engineering**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture: 2 SWS; exercises incl. laboratory + project work (presentation): 2 SWS
Professor in charge Lecturer	PD Dr.-Ing. Ulrich Krupp
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Basic knowledge in Physics
Contents	• Introduction: historic development - the engineering design process • Atomic structure of materials • Materials properties and testing: -Mechanical properties - mechanical testing (+lab) -Electric and magnetic properties -Thermal and optical properties • Materials Design -Phase diagrams (+lab) -Heat treatment (hardening of steels, precipitation hardening, recrystallization) • Engineering Materials -Steel and cast irons (+ excursion to steel plant) -Non-ferrous alloys -Ceramics -Polymers • Materials degradation • Materials selection Project work + presentations on new materials concepts
Learning objectives	– Lecture and exercises should enable the students to understand the basic differences of the classes of materials used in engineering, to correlate functional and structural properties with the microstructure on different length scales (electronic, atomic/nano, micro and macro). The students should achieve the ability to select materials and thermomechanical treatment procedures, as well as materials testing methods, in a systematic way for engineering applications.
Recommended literature	William D. Callister jun.: Materials Science and Engineering. An Introduction. John Wiley & Sons Inc. 1999 Michael F. Ashby, David R. H. Jones: Engineering Materials 1. Butterworth Heinemann, Oxford 2001

	Lecture notes: www.mb.uni-siegen.de/LMW (downloads / lecture _print.ppt)
Examination	K2 (written exam, 2 hours)

Title	**Machine Elements**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture : 4 SWS
Professor in charge Lecturer	Dr.-Ing. Martina Zimmermann
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Basic knowledge in Mechanics
Contents	• Introduction • Fundamentals of strength analysis • Axles and shafts • Rolling and slide bearings • Couplings and clutches • Gear systems • Belt and chain drive systems This lecture gives a basic overview of the major machine elements in the field of mechanical engineering. Their functions and their interaction in machine systems will be explained, advantages and disadvantages presented. On the basis of the fundamental methods of strength analysis the design and dimensioning of exemplary machine elements is taught.
Learning objectives	After taking this lecture the student should be able to correctly select machine elements with regard to the required application task and to understand the importance of a comprehensive design analysis in order to achieve a successful solution.
Recommended literature	• Fundamentals of Machine Component Design Robert C. Juvinall, Kurt M. Marshek John Wiley & Sons; ISBN: 0471244481; 3rd Bk&cdr edition (March 2000) • Standard Handbook of Machine Design Joseph E. Shigley (Editor), Charles R. Mischke (Contributor), Charles R. Mishchke McGraw-Hill Professional Publishing; ISBN: 0070569584; 2nd edition (June 1, 1996) • Machine Elements in Mechanical Design Robert L. Mott Prentice Hall; ISBN: 0138414467; 3rd edition (January 15, 1999) • Fundamentals of Machine Elements Bernard J. Hamrock McGraw-Hill Higher Education; ISBN: 0072289333; Bk&Cd Rom edition (December 22,

	1998) • Lecture notes available from Dr. Zimmermann or via Internet: www.mb.uni-siegen.de/LMW/Downloads-Prints/ME-Downloads
Examination	K2 (written exam, 2 hours)

Title	**Automation & Industrial Communication** **Part 1** Applications of Manufacturing Automation
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture: 2 SWS; exercises: 2 SWS (in the 1st part of the semester)
Professor in charge Lecturer	Prof. Dr.-Ing. Peter Scharf
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Practical training in an industrial manufacturing plant is desirable
Contents	**Part 1.1 Automation in Production Systems** 1. Manufacturing Industries and Products 2. Product / Production Relationsships 3. Production Systems Facilities 4. Manufacturing Support Systems 5. Automation in Production Systems 6. Aspects pro and contra Automation **Part 1.2 Numerical Control** 1. Introduction 2. Basic components of an NC-System 3. Development steps of the NC-Technology 4. Applications of numerical control 5. Types of NC-Systems 6. NC-Programming **Part 1.3 Industrial Robotics** 1. Introduction 2. Robot Anatomy and Related Attributes 3. Joint Drive Systems 4. Robot Control Systems 5. End Effectors 6. Sensors in Robotics 7. Robot Programming 8. Industrial Robot Applications **Part 1.4 Automated Assembly Systems** 1. Fundamentals of Assembly Automation 2. Configurations of Assembly Systems 3. Line Balancing 4. Parts Delivery at Workstations 5. Performance of Multi-Station Assembly Systems 6. Transfer Lines with Storage Buffers
Learning objectives	The student knows the most important tasks and

	approaches for automatic manufacturing systems, for its control systems and for communication. He/she is able to select an appropriate configuration of automation modules for a given manufacturing task and he knows to consider the aspects of a computer based manufacturing support system. In particular he/she is able to plan manufacturing systems with Computerized Numerical Control (CNC), with Industrial Robots (IR) and with Automated Assembly Systems. This **part 1 (**Applications of Manufacturing Automation) must be completed with the **part 2** (Control Systems and industrial Communication) in order to complete the entire lecture.
Recommended literature	Groover, Mikell P.: Automation, Productions Systems and Computer-Integrated Manufacturing. 2nd Edition. Prentice Hall, 2001. Lecture notes availble from Prof. Scharf: Part 1: Automation in Production Systems Part 2: Numerical Control Part 3: Industrial Robotics Part 4: Automated Assembly Systems
Examination	K1 (written exam, 1 hour)

Title	**Automation & Industrial Communication** **Part 2** Control systems and Industrial Communication
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture: 2 SWS; exercises: 2 SWS (in the 2nd part of the semester)
Professor in charge Lecturer	Prof. Dr.-Ing. Günter Schröder
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Basic course in electrical engineering
Contents	**Part 1 Introduction to the fundamentals of industrial automation** • Differentiation according to the program structure • Differentiation according to the hierarchical asignment **Part 2 Software of PLCs** **Part 2.1 Organization of the operational software in PLCs** • Cyclic operation • Alarm controlled operation • Time controlled operation • Language elements of the application software • Binary operations • Algebraic operations **Part 2.2 Kinds of representation of the application software** • Statement list (STL) • Function block diagram (FBD) • Ladder diagram (LAD) **Part 2.3 Sequential control** • Steps • Transitions • Actions • Rules of program flow **Part 3 Interfaces to the process and between automation devices** **Part 3.1 Interface to the process** • Bit-/ Byte- /Word-oriented I/O • Counter inputs • Analog I/O • Isolation and separation amplifiers • Conversion of analog values to digital • Conversion of digital values to analog

	Part 3.2 Interfaces to other automation devices • Serial point-to-point link (RS 232-C, TTY) • Networks: Topologies • Transmission methods: RS 485 • Selected communication systems: PROFIBUS, INTERBUS-S
Learning objectives	The students learn how to solve typical automation problems by using state-of-the-art hardware and software components. He/she is able to select an appropriate configuration of automation modules for a given manufacturing/production task and he/she knows how to connect distributed intelligent automation devices. This **part 2** (Control Systems and industrial Communication) must be completed with the **part 1** (Applications of Manufacturing Automation) in order to complete the entire lecture.
Recommended literature	Gary Dunning: Introduction to Programmable Logic Controllers, 2nd edition, Delmar Thomson Learning. Hackworth & Hackworth: Programmable Logic Controllers, Pearson Education, 2004. Lecture notes availble from Prof. Schröder and via the Internet: Mechatronics-PLCenglish.pdf Mechatronics-Aut-Comm.pdf
Examination	K1 (written exam, 1 hour)

Title	**Fluid Power**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS ; exercises : 1 SWS, lab : 1 SWS
Professor in charge and Lecturer	Prof. Dr.-Ing. Thomas Carolus
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Basics in thermo- and fluid dynamics as taught in any engineering course
Contents	<u>Lecture</u> • Introduction (hydrostatic vs. hydrodynamic principle, fluid power drives - the general idea, applications, fluid power systems in competition with other technologies, brief history, economic importance) • Basic hydromechanic and thermodynamic concepts (Pascal's law and its application in cylinders, motors, pumps and transmissions, first law of thermodynamics, equation of continuity, pressure loss, choked nozzle) • The working fluids (hydraulic oils and alternative fluids (inflammable, biodegradable), compressed air) • Hydraulic components (pumps and motors, actuators, valves (directional control valves, check valves, pressure and flow valves, proportional and servovalves, fluidics), accumulators, ancillary devices) • Pneumatic components (air preparation, valves, sensors, peculiarities of pneumatic actuators) • Circuits (elementary circuits, operating sequence diagram) <u>Exercises</u> Each chapter features an selection of review questions and review problems. <u>Laboratory work</u> 6 laboratory exercises (basic pneumatic circuits, valve switching time and oscillator circuit, stepper, time-displacement diagram of an actuator, electropneumatic circuit, programming of a servopneumatic axis)
Learning objectives	To provide an understanding of the basic concepts, the physical background and the state-of-the-art components in (oil) hydraulics and pneumatics. Students will be able to apply fluid power technology to solve basic and advanced engineering problems and to understand complex mechatronics systems combining fluid power, electric and electronic (microprocessor controlled) control.

Recommended literature	• Th. Carolus: Fluid Power, Lecture Notes, University Siegen, 2004 • F. Don Norvelle: Fluid Power Technology, West Publishing Company, 1994 • Festo Didactic: Lehrmaterial zur Pneumatik und Elektropneumatik
Examination	K2 (written exam, 2 hours)

Title	**Basic Control**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture: 1.5 SWS; exercises: 0.5 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Robert Mayr
Held in semester	WS (first half of the semester)
Medium of instruction	English
Knowledge prerequisites	Basic knowledge in Mathematics (especially differential equations) and Physics
Contents	The course covers classical control theory, which is based on the analysis of control circuits in the frequency domain. Properties as stability, freedom of periodic oscillations and freedom of a steady state control deviation even in case of disturbances are explained. Flow diagrams, linear controllers and algebraic as well as graphical stability criteria are included in the lecture. The topics in detail are: - Flow diagram and its components; - Structure of a control circuit; - Step response; - Laplace Transformation; - Characteristic equation of a polynomial; - Flow diagram algebra; - Complex s-plane; - Linear time invariant transfer elements; - Application of PID-controllers; - Hurwitz criterion; - Root locus; - Nyquist criterion; - Bode diagram. In the exercises related examples are presented.
Learning objectives	The objective of the course is that the students will be able to understand the dynamical behaviour of control circuits. Thus, they can design and analyse linear control systems in the frequency domain. These skills are also necessary prerequisites for the upcoming courses in Advanced Control I and II.
Recommended literature	Gene F. Franklin, J. David Powell, Abbas Emami-Naeini Feedback Control of Dynamic Systems, Prentice Hall, 2005, 5th edition

	ISBN: 0131499300
Examination	K1 (written exam, 1 hour)

Title	**Advanced Control I**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture: 1.5 SWS; exercises: 0.5 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Robert Mayr
Held in semester	WS (second half of the semester)
Medium of instruction	English
Knowledge prerequisites	Basic knowledge in Mathematics (especially differential equations, linear algebra) and Physics, Course Basic Control
Contents	The modern control theory is based on methods, where the system representation is performed in the time domain. Control systems for single input/output systems as well as for multivariable systems are explained. On top of that, also estimators for non measurable variables as well as basic issues for the description of nonlinear systems are presented. The topics in detail are: - Description of systems in state space; - Controllability, observability; - Eigenvalues, eigenvectors; - Equivalent system transformation; - The canonical forms; - State feedback control; - Observers; - Decoupling of multivariable systems; - Nonlinear systems in state space; - Feedback linearization. In the exercises related examples are presented.
Learning objectives	The objective of the course is that the students will learn methods for control design directly in the time domain. As high order, multivariable and nonlinear systems are included, the students will be able to design controllers in a very complex environment.
Recommended literature	Gene F. Franklin, J. David Powell, Abbas Emami-Naeini Feedback Control of Dynamic Systems, Prentice Hall, 2005, 5th edition ISBN: 0131499300
Examination	K1 (written exam, 1 hour)

Title	**<u>Project Management I</u>**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS
Professor in charge Lecturer	Prof. Dr.-techn. Gerald Adlbrecht
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Basic knowledge in Systems Theory
Contents	The course contains class lectures and group work and starts with theoretical considerations of systems theory and heuristics. After investigating the relevant aspects of project initiation, all major methods and tools of project planning and project control and the assistance of computers in project management is explained. • Heuristics and Systems' Theory • Project Definition and Goal Setting • Project Structuring, Scheduling and Resource Planning • Project Control and Monitoring Project Progress • Computer Basics for Project Work • Project Management Systems
Learning objectives	The Project Management 1 course focuses on the set of modern methods and instruments to plan and control the process of innovation and investment projects. The objective of this basic course is to prepare students for their future managerial tasks as project team member, project coordinator, or project controller. Upon completion of the course, students should have the knowledge to prepare the project kick-off, should be able to structure projects, to plan, and control projects in terms of time, cost, and quality throughout all project stages from initialisation to handing over
Recommended literature	Turner, J.R., Simister, S.: Gower Handbook of Project Management ISBN 0 566 08138 5, Gower Publishing Ltd., England Lock, D.: Project Management, Seventh Edition,ISBN 0 566 08225 X, Gower Publishing Ltd., England.
Examination	K1 (written exam, 1 hour)

Title	**<u>Electrical Machines and Power Electronics</u>**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS ; exercises : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. J. Mario Pacas
Held in semester	Summer semester
Medium of instruction	English
Knowledge prerequisites	Basic knowledge of Electrical Engineering Bachelor Level or Course Electrical and Electronic Engineering in Mechatronics Program
Contents	Power Electronics • Overview of power semiconductors switches • DC-DC converters • Power supplies • DC-AC converters • Line frequency AC-DC converters • Resonant converters Electrical Machines • Electrical machines and mechatronics • DC machines • Induction machine • PM-Synchronous machines • Step motors Exercises and laboratory sessions are part of this course.
Learning objectives	This course builds the fundaments for the course "Actorics" and introduces the most important chapters of electrical machines and power electronics. The student get acquainted with the steady state behavior of the most important machines in industrial and mechatronic applications and with the power electronics circuits used in the control of machines and in switched power supplies. After this course the students have the background for the understanding of drives and actuators that include electrical machines and power electronics.
Recommended literature	• Mohan, N; Undeland, T; Robbins, W: Power electronics, Converters, Applications and Design, John Wiley & Sons, Inc, Snd Edition

	1998 • B.K. Bose: Power electronics and AC Drives, Prentice-Hall, Englewood Cliffs, New jersey • R. Erickson, D. Maksimovic: Fundamentals of Power Electronics, Kluwer Academic Publishers • Rashid, Muhammad H.: Power electronics : circuits, devices, and applications, Englewood Cliffs, N.J. : Prentice-Hall • El-Hawary, M. E.: Principles of electric machines with power electronic applications, Englewood Cliffs, NJ : Prentice Hall • DelToro, Vincent:Electric machines and power systems, Englewood Cliffs, N.J. : Prentice Hall
Examination	K2 (written exam, 2 hours)

Title	**Engineering Design I**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture/exercises : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Rainer Lohe
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	
Contents	A summary of the **content** is Terms and definitions • Functions • Assignment of functions • Function structure • Function carriers • Function costs • Value • Value analysis • Other design methodologies The Management of a design project • Value analysis work plan • How to prepare a project • How to analyse and describe the current situation • How to describe the intended status • How to apply idea-finding techniques • How to develop and evaluate solutions and prepare decisions • How to put the selected solution into practice
Learning objectives	It is the aim of this course to teach the students the basics of Design Methodologies in order to encourage them towards a systematic approach to new industrial design projects. The **learning outcomes** are to comprehend • the basic rules in design projects • the systematic approach to design work • the advantages and disadvantages of teamwork • the co-ordination and the moderation of teamwork • the differences and the common features of different design methodologies • the Value Analysis work plan

Recommended literature	Lohe, R.: Konstruktionstechnik 1, Vorlesungsbegleittext; Universität Siegen 2005
Examination	K1 (written exam, 1 hour)

Title	**<u>Engineering Design II</u>**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture/exercises: 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Rainer Lohe
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	
Contents	A summary of the content is • Cost carriers • Department costs • Advantageous design examples • Function costs • Part series • Product series • Part series systems • Dimensioning theory • Cost prediction
Learning objectives	It is the aim of this course to teach the students an enhanced understanding of cost and value and their correlation to design in industry. The learning outcomes are to comprehend • the relationship between costs, design and manufacturing facilities • the relationship between costs, reliability, risk and quality • Cost and calculation basics in companies
Recommended literature	Lohe, R.: Konstruktionstechnik 2, Vorlesungsbegleittext; Universität Siegen 2005
Examination	K1 (written exam, 1 hour)

Title	**<u>Introduction to Programming</u>**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture: 2 SWS; laboratory: 2 SWS
Professor in charge Lecturer	Prof. Dr. Roland Wismüller
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	Students should have a basic understanding of computers and Computer Science.
Contents	The course introduces the basic concepts of computer programming, with emphasis on the requirements of engineering students. It deals with sequential, imperative and object-oriented programming, using the C++ programming language. The lecture is accompanied by a series of programming assignments. Detailed contents of the lecture: – Introduction: algorithms and programs – Data: variables, types and constants – Statements: expressions, conditional statements, loops – Exception handling – Functions and recursion – Data structures: arrays and structures – Pointers, references, memory allocation – Classes: attributes, methods, constructors, destructors, operators – Object oriented programming: inheritance, polymorphism, abstract classes – Container classes, standard template library
Learning objectives	The students learn how to write simple computer programs. This includes technical programming skills in C++, but also methodical skills like the systematic transformation of algorithms into programs and the use of object-oriented concepts.
Recommended literature	J. Liberty. Teach Yourself C++ in 10 Minutes. Sams Publishing, 1999 (or: second Ed., 2002) Bruce Eckel: Thinking in C++, 2nd Edition http://mindview.net/Books/TICPP/ThinkingInCPP2e.html
Examination	P (practical coursework with grade)

Title	**Advanced Control II**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture/exercises : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Hubert Roth
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	Advanced Control I
Contents	– description of digital control systems with the z-transformation – z-transfer-functions in the control loop – design of different types of digital controllers – basics of optimal control systems
Learning objectives	The purposes of this course are to get used to the z-transformartion and the applications in digital control systems. Students will become acquainted with the use of z-transfer-functions in the control loop and the design of digital controllers.
Recommended literature	Gene F. Franklin; J. David Powell, Michael L. Workman: “Digital control of dynamic systems”. Isermann, Rolf: “Regel- und Steueralgorithmen für die digitale Regelung mit Prozessrechnern”. Brian D. O. Anderson; John B. Moore: “Optimal control: linear quadratic methods”. Föllinger, Otto: “Optimale Regelung und Steuerung”. Föllinger, Otto: ″Lineare Abtastsysteme“. Wolfgang Latzel: “Einführung in die digitalen Regelungen”. Hung V. Vu; Ramin S. Esfandiari: “Dynamic Systems“ Martin Horn; Nicolas Dourdoumas: “Regelungstechnik” Richard C. Dorf; Robert H. Bishop: „Modern Control Systems“ J. Lunze: “Regelungstechnik 2, Mehrgrößensysteme, Digitale Regelung“ Holger Lutz; Wolfgang Wendt: „Taschenbuch der Regelungstechnik“
Examination	K1 (written exam, 1 hour)

Title	**Machine Dynamics & System Dynamics**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture: 2 SWS; exercises/tutorial: 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Claus-Peter Fritzen
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	Basic course in Engineering Mechanics (Statics, Dynamics) or Applied Physics on undergraduate level
Contents	Topics covered are: • Kinematics of Particles and Rigid Bodies (Rotation Matrices, Euler and Cardan angles, Holonomic and Non-holonomic Constraints), • Kinetics of Point Masses and Rigid Bodies (Momentum and Angular Momentum, Newton's and Euler's Law, Work-Energy Principles, Lagrange's Equations of Motion, State Space Representation), • Overview on Vibration Phenomena, Vibrations of Linear Systems with a Single Degree of Freedom (Equation of Motion, Free Vibrations, Damping, Forced Vibrations from Harmonic and General Periodic Excitation, Excitation by Impacts, Excitation by Forces with Arbitrary Time Functions), Isolation of Vibrations • Vibrations of Systems with Multi Degrees of Freedom (Equations of Motion, Free Undamped Vibrations, Eigenvalue Problem, Natural Frequencies, Mode Shapes, Modal Matrix, Orthogonality of Modes, Forced Vibrations), Passive Vibration Absorbers • Active Damping, Mechatronic Systems and Smart Structures.
Learning objectives	The aim of the course is to get a deeper insight into the principles to describe the kinematics and dynamics of mechanical systems. Examples and exercises from robotics, vehicle dynamics or rotating systems will illustrate the mathematical description and consolidate the methods learned. The student should be able to analyse and model the systems' dynamics and describe them by their equations of motion. Basic solution techniques are treated to predict the evolution of the system's state, especially in terms of displacement, velocities and accelerations as well as

	dynamic internal forces and moments in machines and structures. The student will also get a basic understanding of important vibration phenomena (forced, parametric and self-excited vibrations) and should be able to analyse the vibration behaviour of single and multiple degree of freedom systems. Interfaces to other disciplines especially to modelling and simulation and control are pointed out. .
Recommended literature	1) Fritzen, C.-P., “Machine and System Dynamics”, Lecture Notes, Univ. of Siegen, 2004 2) Ginsberg, J.H., “Advanced Engineering Dynamics”, 2nd edition, Cambridge Univ. Press, 1998 3) Moon, F.C., “Applied Dynamics: With Applications to Multibody and Mechatronic Systems”, John Wiley & Sons, 1998 4) Inman, D.J., “Engineering Vibrations”, Prentice Hall, 1994 5) Ginsberg, J.H., “Mechanical and Structural Vibrations- Theory and Applications”, John Wiley, 2001
Examination	K2 (written exam, 2 hours)

Title	**Sensorics**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS ; exercises : 2 SWS
Professor in charge Lecturer	PD Dr. Günter Stöhr
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	Basic knowledge in Mechanics, Physics, Mathematics, Electrical Engineering
Contents	Introduction to Sensors and Transducers Classification of transducers Transducer descriptions Transducer parameters, definitions and terminology Piezoresistance Piezoelectricity Capacitive sensor Inductive sensor Thermoelectric sensor Accelerometer Pressure sensor Flow sensor Chemical sensor Radiation sensor Pyroelectric Sensors Galvanomagnetic Sensors Ultrasonic Sensors
Learning objectives	This lecture is intended to overview about the basic principles of various sensors, including basic calculation such as piezosensor, strain gage, capacitance sensor, pressure sensor, flow sensor and also provide an overview about main characteristics of sensors for example sensitivity, accuracy, noise (white noise), linearlity. The lectures also including the methods for measurement of position/acceleration, pressure/force, flow, temperature and etc.
Recommended literature	1. Shetty, Devdas, Richard A. Kolk: Mechatronics system design , PWS Publ. Co., 1997. - IX, 422 p. ISBN 0-534-95285-2 2. Bolton, William: Mechatronics : electronic control systems in mechanical engineering Addison Wesley Longman Ltd., 1996. - XI, 380 p. ISBN 0-582-25634-8 3. Grattan, Kevin T. V. [Hrsg.]: Sensors : Technology, Systems And Applications / ed. By K. T. V. Grattan Bristol [u.a.] : Hilger, 1991. - XIII, 559 S. : Ill., zahlr. graph. Darst. (The Adam Hilger series on sensors)

	ISBN 0-7503-0157-0 4. Brindley, Keith: Sensors And Transducers London [u.a.] : Heinemann, 1988. - 153 S. : Ill., graph. Darst. ISBN 0-434-90181-4 5. Sinclair, Ian R.:Sensors And Transducers : A Guide For Technicians Oxford [u.a.] : BSP Professional Books, 1988. - XI, 153 S. : Ill., graph. Darst. ISBN 0-632-02069-5
Examination	K2 (written exam, 2 hours)

Title	**Mechatronic Design in Production Machines**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture/exercises : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Armin John
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	
Contents	**1. Introduction** • Review of history in the design and construction of production machines • Definition of Mechatronics in the industry of production machines • Technical systems in general • Basic structure of a mechatronic system • Embedding of mechatronic systems in higher layers of automation • Different types of production machines • Typical bloc-diagram of a modern production machine • Presentation of a “Flat Metal Processing Line” as example **2. Project Management** 2.1 Definition • Specification • Standards and directives 2.2 Basic Engineering and Performance calculation • Process data, performance and production curve • Accuracy, resolution, tolerance and real-time control constraints 2.3 Interaction between mechanics and electronics: Mechatronics • Engineering of drives, gear boxes, clutches, couplings and brakes (Details of Drives and Power-Electronics see lecture Prof. Pacas) • Engineering of digital and analogue sensors 2.4 Example: “Flat Metal Processing Line”

	• Different versions for different production purposes • Maximum extension for fully automatic production • Different types of cross cutting shears **3. Hydraulics, Pneumatics** (Details see lecture Prof. Carolus) Basic considerations for hydraulics and pneumatics for the performance **4. Cooling** • Cooling systems • Ventilators and blowers • Air-conditioners • Engineering and influence on the performance • Interface to automation • Example: “Flat Metal Processing Line” **5. Communication** (Details see lecture Prof. Schroeder) • WAN, LAN, Field-busses • Horizontal and vertical integration • Considerations for Engineering • Example: “Flat Metal Processing Line” **6. Cabinets and Wiring** • Standards and directives • Engineering • Power- and signal cable trays • Grounding and shielding • Example: “Flat Metal Processing Line” **7. Documentation** • Standards • Safety aspects • Language • Example: “Flat Metal Processing Line” **8. Commissioning, startup, customer acceptance** • Planning for commissioning • Consideration for availability • Spare parts • Maintenance

	• After sales service • Example: “Flat Metal Processing Line” **9. Commercial and legal considerations** • Calculation (pre- and post-) • Risks • Sales order confirmation • Terms and conditions • Warrantee • Example: “Flat Metal Processing Line”
Learning objectives	Implementation of mechatronic theory in industrial production machines.
Recommended literature	will be published during the lecture.
Examination	P (practical coursework with grade)

Title	**Project Management II**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS
Professor in charge Lecturer	Prof. Dr.-techn. Gerald Adlbrecht
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	Project Management 1
Contents	The course contains class lectures and group work and starts with engineering business and its organisational background. After investigating the relevant aspects of project tendering, all major managerial aspects are dealt with. • Special issues of engineering and construction business • Prequalification and tendering • Makro-organisation, contracting, and subcontracting • Risk management and financial engineering • Procurement and logistics • Introduction to contract law and claim management
Learning objectives	The Project Management 2 course focuses on the application of project management in its most extensive field: Machinery and plant engineering and construction. The objective of this basic course is to examine the management tasks from a contractor's point of view from prequalification to handing over of the plant or machinery to prepare students for their future managerial tasks as project team member, project coordinator, or project manager. Upon completion of the course, students should have the knowledge about the most important specific processes throughout the project, to prepare bids, organise financial engineering, set up procurement, contract, risk, and claim management.
Recommended literature	Turner, J.R.: Commercial Project Manager ISBN 0-07-707946-9, McGraw-Hill, 1995 Austen, A.D., Neale, R.H.: Managing Construction Projects, ISBN 92-2-103553-0 International Labour Office Geneva, 1986.
Examination	K1 (written exam, 1 hour)

Title	**Actorics**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS ; exercises : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. J. Mario Pacas
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Electrical Machines and Power Electronics Basic knowledge of Control

Contents	• Mechanics
	• Fundamentals of electrical actuators
	• Types of machines and characteristics
	• Main issues in the design of electromechanical systems
	• Current sensors
	• Angular and length sensor
	• Current control
	• Speed control
	• Position control
	• Torque control
	    • DC-Machine
	    • Field orientation
	    • AC-Machines
	
	Exercises and laboratory sessions are part of this course.

Learning objectives	The course is based on the fundaments obtained in "Power Electronics and Electrical Machines" and introduces the theory and practical aspects of the most important electrical actuators, mainly electrical drives, used in industrial and mechatronics applications. The students get acquainted with the function and especially with the dynamic behavior of these devices. The torque, speed and position control of electrical drives and the implementation of the control schemes with appropriate electronics is in the main focus of the course.
Recommended literature	• Mohan, N; Undeland, T; Robbins, W: Power electronics, Converters, Applications and Design, John Wiley & Sons, Inc, Snd Edition 1998 • R. Erickson, D. Maksimovic: Fundamentals of Power Electronics, Kluwer Academic Publishers

	• Rashid, Muhammad H.: Power electronics : circuits, devices, and applications, Englewood Cliffs, N.J. : Prentice-Hall • DelToro, Vincent: Electric machines and power systems, Englewood Cliffs, N.J. : Prentice
Examination	K 2 (written exam, 2 hours)

Title	**<u>Modeling and Simulation 1 & 2</u>**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture : 3 SWS ; exercises : 1 SWS
Professor in charge Lecturer	Prof. Dr. Wolfgang Wiechert
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	For M&S 2 : few parts of M&S 1
Contents	The lectures on „Modeling and Simulation 1&2" which are part of the mechatronics master course are given in two successive half semesters during fall and winter. Each course integrates lectures, demonstrations, written exercises and computer exercises. „Modeling and Simulation 1" is concerned with a basic understanding of simulation methods. The general course of a simulation study including problem specification, mathematical modeling, simulator implementation, model validation, problem solution, and presentation of results is discussed with the simple example of a boat swing. Then some typical simulation tools for different scientific disciplines (mechanical multibody systems, electrical circuits, control engineering) are roughly introduced. The next topic is the use of random number generators for the simulation of stochastic influences on dynamic systems. For this purpose some basics from probability theory and statistics are required. Finally, the simulation of discrete event systems is discussed, which is of great importance for automation systems and digital circuits. „Modeling and Simulation 2" deals with the simulation of time continuous systems which are described by differential equations or time dependent equation systems. Such systems are encountered in kinematics, multibody systems, continuum mechanics, electrical circuits, hydraulic systems, or continuous control systems. Working with the corresponding simulation tools requires a more detailed understanding of the involved numerical algorithms. The numerical solution of ordinary differential and nonlinear time dependent equation systems is explained with various simple examples. In particular

	the treatment of stiff and differential algebraic systems is discussed, which are of great importance for mechatronics and modern continuous time simulation tools. Summary: 1. Application domains of simulation 2. Course of a simulation study 3. Typical time continuous simulation tools 4. Basic concepts of stochastic simulation 5. Discrete event simulation 6. Numerical solution of ordinary differential equations 7. Treatment of stationary and quasi-stationary systems 8. Stiff and differential algebraic equations
Learning objectives	In the engineering sciences simulation means the reproduction of a dynamic system on a digital computer. Especially, for mechatronic systems the aim of simulation is to obtain a deeper understanding of the system behaviour, to accelerate the product development cycle, to efficiently develop controllers, and to optimize existing and future systems. Mechatronics is a challenging application field of simulation methods and various simulation tools for multibody systems, electrical circuits, hydraulic components, or control systems are already commercially available. However, the proper use of such tools requires some basic knowledge about mathematical modeling, simulation methodology, numerical algorithms, and statistical data evaluation. To impart these capabilities is the major aim of the simulation courses.
Recommended literature	The following material is available on the Internet. See “Materialien” on www.simtec.mb.uni-siegen.de : 1. Skriptum of lectures Modeling & Simulation 1&2 (in German language) 2. Power point presentations of all lectures (in English language) 3. MATLAB examples presented in the lectures 4. Additional material (exercises, MATLAB introduction etc.)
Examination	K2 (written exam, 2 hours)

Title	**S/W Engineering**
Credit points	5
Module elements (Lecture/exercises/lab)	Lecture: 2 SWS; exercises: 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Madjid Fathi Torbaghan
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	C++ or Java programming
Contents	- process models (waterfall model) - object-oriented analysis using UML class diagrams - object-oriented design - use cases - state charts - petri net models - software architectures - configuration management using CVS - project homework
Learning objectives	To intensify the first programming experience gained in the course Introduction to Programming; to learn basic techniques of how to manage software development projects; to be able to develop documents of the early software development phases, notably data models, control models and design models using the Unified Modelling Language (UML)
Recommended literature	http:// uml_tutorial.pdf www.omg.org/technology/documents/modeling_spec_catalog.htm
Examination	P (practical coursework with grade)

Title	**Mechatronic Systems**
Credit points	7.5
Module elements (Lecture/exercises/lab)	Lecture : 2 SWS ; exercises : 2 SWS, lab : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Hubert Roth
Held in semester	WS
Medium of instruction	English
Knowledge prerequisites	Advanced Control II
Contents	- Characteristics of mechatronic systems - Sensors and actuators for mechatronic systems - Modelling - Identification - Control concepts for mechatronic systems - Typical examples of integrated mechanical – electrical systems - Project management skills
Learning objectives	The course “Mechatronic Systems” completes the studies by enhancing and deeping aspects of automatic control engineering, modelling and project management. Main topics are modelling, linearization, discretization, order reduction techniques and system identification. The course also includes a group project for practical application of mechatronic knowledge. Purposes of the course are to - Design and analyse mechatronic systems as an optimal combination of mechanical, electrical and software components - Demonstrate the advantage of mechatronic systems in different application areas - Get experience with mechatronic systems by performing different laboratory experiments - Apply project management skills with respect to o Rhetoric o Risk management and financial planning o Project structuring, scheduling and resource planning o Project control and monitoring
Recommended literature	- R. Isermann: Mechatronische Systeme, Springer Verlag, 1999. - Schilling: Fundamentals of Robotics, Prentice Hall. - Craig: Robotics, Addison Wesley. - Ljung: System Identification, Prentice Hall, 1987, ISBN 0-13-881640-9.

	- W. Bolton: Bausteine mechatronischer Systeme, 3. Auflage, Pearson Studium, 2004, ISBN 3-8273-7098-1. - J. Billingsley: Mechatronics and Machine Vision, Research Studies Press Ltd., 2000, ISBN 0-86380-261-3. - Emerging Trends in Mechatronics for Automation, Phoenix Publishing House PVT LTD, 2002, ISBN 81-7484-065-6. - Chr. D. Rahn: Mechatronic Control of Distributed Noise and Vibration, Springer Verlag, 2001, ISBN 3-540-41859-8. - D. Nesculescu: Mechatronics, Prentice Hall, 2002, ISBN 0-201-44491-7.
Examination	K3 (written exam, 3 hours)

Title	**Control Laboratory**
Credit points	2.5
Module elements (Lecture/exercises/lab)	Lab : 2 SWS
Professor in charge Lecturer	Prof. Dr.-Ing. Hubert Roth, Prof. Dr.-Ing. Robert Mayr, Dipl.-Ing. Martin Rühl, Dipl.-Ing. Peter Will
Held in semester	SS
Medium of instruction	English
Knowledge prerequisites	Basic Control, Advanced Control I u. II
Contents	Practical simulation and hardware experiments regarding the contents of the courses in Basic Control and Advanced Control I and II.
Learning objectives	The purposes of the laboratory are to realize and understand the control structures given in the lectures. The theory given in the lectures Basic Control, Advanced Control I and Advanced Control II are demonstrated at real hardware and simulation experiments. The students will learn to install control algorithms to real systems and to test closed loop dynamics. They will be experienced in professional tools for the simulation of real systems
Recommended literature	Laboratory experiment descriptions on the mechatronics WebPages at http://www.uni-siegen.de/rst Guideline for laboratories at Universität Siegen on the mechatronics WebPages at http://www.uni-siegen.de/rst Experiment descriptions on the venture page http://www.quanser.com K.H. Schmidt, Untersuchungen am Regelkreis mit Schrittmotorstellglied, Der Elektroniker, 1973 K.H. Schmidt, GRS Handbuch zum Schrittmotor-Lehrversuch, Firmenschrift der Gesellschaft für Regelungs- und Simulationstechnik GmbH, 1975 J. Schwarzenbach, K.F. Gill, System Modelling and Control, Arnold, 1984 J. Lunze, Regelungstechnik 2, Springer Verlag, 2002 R. Isermann, Digitale Regelsysteme, Springer Verlag, 1987 Gene F. Franklin, J. David Powell, Abbas Emami-Naeini Feedback Control of Dynamic Systems, Addison-Wesley Pub Co., Nov. 1993, 3rd edition ISBN: 0201527472
Examination	P (practical coursework)

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