University of Siegen

ECTS Brochure for the International Graduate Studies in Mechatronics

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Embedded Control

Lecturer:
Dr.-Ing. Ralf Gödde

Learning objectives:
- 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.

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.

Examination:
The written examination has a duration of 2 hours. No aids are allowed (except of a pen and a pocket calculator).

Recommended Literature:
Some sheets will be handed out.
For operating systems the following book is used: Stallings, W.: Operating Systems (Internals and Design Principles).
But it is not necessary to own/purchase this book!

Electrical and Electronical Engineering

Lecturer:
Prof. Dr.-Ing. Bernhard Bundschuh

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.

Contents:
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

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

Electromagnetic Fields
Electric Forces and Electric Fields
Magnetic Forces and Magnetic Fields
Electrodynamics

Examinations:
There is a two hour written examination. During this time the students must solve a certain number (typically 6) of test problems by calculation using methods taught in the course.

Recommended Literature:
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

Foundations of electrical engineering - J. R. Cogdell - Prentice Hall

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

Materials Science and Engineering

Lecturer:
Dr.-Ing. Ulrich Krupp

Learning objectives:
The following objectives of learning should be achieved:

- To enable the student to understand the basic differences of the classes of materials used in engineering
- To enable the stundent to correlate microstructure and mechanical properties of materials
- To enable the student to select materials and heat treatments for different engineering applications
- To enable the student to select suitable characterization and testing procedures in order to obtain the data needed for the particular engineering application

Contents:

1. Historic development of materials
2. Materials testing + laboratory course
3. Metallography + laboratory course
4. Atomic structure and microstructure
5. Mechanical properties
6. Multi-phase materials
7. Fundamentals of heat treatment
8. Standardization
9. Steels and cast irons + excursion to a steel plant
10. Aluminium alloys
11. Ceramics
12. Polymers
13. Composites

Examination:
Written exam of 2 hours at the end of the term

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: http://www.mb.uni-siegen.de/e/ifw2/indexl.htm

Machine Elements

Lecturer:
Dr.-Ing. Martina Zimmermann

Learning objectives:
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. 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.

Contents:

1. Introduction

   - design structure of machines and their elements
   - energy transmitting devices
   - support and bearing elements
   - seals
   - joining devices

2. Fundamentals of strength analysis

   - analysing load situation of parts
     - modes of stress
     - strains
     - stress theories
     - static and dynamic loading
   - behaviour of materials at static and dynamic loads
     - stress-strain diagram
     - Wöhler, Smith and Haigh diagram
   - stress concentration due to notch effects

3. Axles and shafts

   - differences between axles and shafts
   - materials and manufacturing
   - shaft extensions
   - types of connections
   - notch effects and strain line courses in shafts
   - designing procedure of axles and shafts
   - designing procedure of fitting key connections

4. Rolling and slide bearings

   - structure of rolling element bearings
   - types of rolling element bearings

- examples for rolling bearing arrangements
- designing procedure of rolling bearings
- modes of friction
- comparison between rolling and slide bearings
- hydrodynamic slide bearings
- hydrostatic slide bearings

5. Couplings and Clutches

   - functions and application
   - classification of couplings and clutches
   - types of couplings
   - types of clutches
   - basic design procedures of couplings and clutches

6. Gear systems

   - functions and applications
     - spur gear
     - helical gear
     - bevel gear
     - worm gear
   - geometry and nomenclature of gear wheels
   - tooth curves
   - basic calculation of the gear wheel geometry
   - basic design procedures and strength analysis

7. Belt and chain drive systems

   - major functions of belt and chain drives
   - major advantages and disadvantages of belt drives
   - types of belt drives
   - classification of belt drive systems
   - application examples
   - major advantages of chain drives
   - major components of a chain drive
   - application examples

Examination:

- at the end of the course (exam period: spring)
- written examination
- 2 hours (full hours)

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)

Automation & Industrial Communication

Part 1 Applications of Manufacturing Automation

Lecturer:
Prof. Dr.-Ing. Peter Scharf

Learning objectives:
It is aim of this lecture to introduce tasks and approaches to solutions for automatic production systems, for its control systems and for communication. The relation between mechatronics and manufacturing is double. Every mechatronical product must be manufactured on the one hand. On the other hand modern production facilities consist predominantly of mechatronical 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.

The content of the part 1 is the following:

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

Examination:
Written Examination at the end of the winter semester

Recommended Literature:
Groover, Mikell P.:
Automation, Productions Systems and Computer-Integrated Manufacturing.
2nd Edition. Prentice Hall, 2001.

Lecture notes are availble in the secretary office of Prof. Scharf:
- Part 1: Automation in Production Systems
- Part 2: Numerical Control
- Part 3: Industrial Robotics
- Part 4: Automated Assembly Systems

Automation & Industrial Communication

Part 2 Control Systems and Industrial Communication

Lecturer:
Prof. Dr.-Ing. Günter Schröder

Learning objectives:
The student will learn about software and hardware of modern industrial automation systems, epecially for PLCs, which are the standard automation devices in the industry. First the principles of runtime and application software are explained. The basic elements of the usual programming languages are presented. Then the interfaces to the process and to the other automation devices will be explained. This covers digital and analog signals, A/D and D/A conversion, absolute and incremental encoders, and field bus systems.

Contents:

1. Introduction to the fundamentals of industrial automation

1.1 Terms

- Differentiation according to the program structure
- Differentiation according to the hierarchical assignment

2. Software of PLCs

2.1 Organisation of the operational Software in PLCs

- Cyclical operation
- Alarm controlled operation
- Time controlled operation
- Language elements of the application software
- Binary operations
- Algebraic operations

2.2 Kinds of representation of the application software

- Statement list (STL)
- Function bloc diagram (FBD)
- Ladder diagram (LAD)

2.3 Sequential control

- Steps
- Transitions
- Actions
- Rules of program flow

3. Interfaces to the process and between automation devices

3.1Interfaces of modern automation devices

- Interface to the process:
  Bit- /Byte-/Word- oriented I/O Counter inputs Analog I/O: -Isolation amplifiers
  -Conversion of analog values to digital
  -Conversion of digital into analog values

3.2 Interfaces to other automation devices

- Serial Point-to-Point-Link (RS232-CTTY)
- Networks: Topologies
  Transmission methods: RS 485
  Selected communication systems: PROFIBUS, Interbus-S

Examination:
2 hours of written examination at the end of the winter semester (one hour Part 1 (Prof. Scharf) and one hour Part 2 described above (Prof. Schröder)).

Recommended Literature:
Gary Dunning: Introduction to Programmable Logic Controllers, 2nd edition, Delmar Thomson Learning.

The following material is available on the internet:
www.lea.et-inf.uni-siegen.de/englisch/SKRIPT_schroeder_eng/Mechatronics-PLCenglish.pdf

www.lea.et-inf.uni-siegen.de/englisch/SKRIPT_schroeder_eng/Mechatronics-Aut-Comm.pdf

Fluid Power

Lecturer:
Prof. Dr.-Ing. Thomas Carolus

Learning objectives:
To provide an understanding of the basic concepts and components in fluid power technology, i.e. in (oil) hydraulics and pneumatics.

Contents:
1. Introduction (hydrostatic vs. hydrodynamic principle, fluid power drives - the general idea, applications, fluid power systems in competition with other technologies, brief history, economic importance)
2. 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)
3. The working fluids (hydraulic oils and fluids, compressed air)
4. Hydraulic components (pumps and motors, actuators, valves, accumulators, ancillary devices)
5. Pneumatic components (air preparation, valves and sensors, cylinders)
6. Circuits
7. Laboratory work

Examination:

- Midterm exam (written examination 1 hour (full hour))
- Lab report
- Final exam (written examination 2 hours (full hours))

Recommended Literature:

Th. Carolus: Fluid Power, Lecture Notes University Siegen, 2002
F. Don Norvelle: Fluid Power Technology, West Publishing Company, 1994

Introduction to Computer Science

Lecturer:
Dipl.-Ing. Dipl.-Math. Michael Engel

Learning objectives:
Understanding the Fundementals of Computer Science
using a bottom-up-approach that covers important topics of Computer Science targeted at engineer's requirements

Contents:
History of Computer Science,
Binary Arithmetics and Logic
Computer Architecture
Operating Systems
Networking
Data Structures
Algorithms
Programming Paradigms
Overview of Programming Languages
Databases
Graphical User Interfaces
Computer Graphics
Embedded and Realtime Systems
Short Introduction to Theoretical CS

Examination:
2 hrs., written Exam

Recommended Literature:
J. Glenn Brookshea: "Computer Science: An Overview"
Format:Textbook Paperback, 7th ed., 592pp.
ISBN: 0201781301
Publisher: Pearson Education
Pub. Date: July 2002

Advanced Control I

Lecturer:
Prof. Dr.-Ing. Robert Mayr

Learning objectives:
The modern control theory is based on methods, where the system representation is performed in the time domain. In the course the students will learn basic strategies for the design of control systems directly in the time domain using the state space description method. Besides, also estimators for non measurable important variables as well as basic issues for the description of nonlinear systems are presented. Comprehensively, the objective is to obtain the ability to design complicate control systems of high order by performing free pole assignment for linear and a certain class of nonlinear systems.

It is expected that the students have a basic knowledge about the classic design of control systems based on the frequency domain

Contents:

- 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,
- nonlinear decoupling,
- simulation.

Examination:
The examination is a written examination taking one hour.

Recommended Literature:
Gene F. Franklin, J. David Powell, Abbas Emami-Naeini
Feedback Control of Dynamic Systems,
Addison-Wesley Pub Co., Nov. 1993, 3rd edition
ISBN: 0201527472

Project Management I

Lecturer:
Prof. Dr.-techn. Gerald Adlbrecht

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.

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 Structuring, Scheduling and Resource Planning
- Project Control and Monitoring Project Progress
- Computer Basics for Project Work
- Project Management Systems

Examinations:
There is one written Final Exam at the end of lecture period.

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.

Electrical Machines and Power Electronics

Lecturer:
Prof. Dr.-Ing. J. Mario Pacas

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.

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.

Examinations:
The examination is closed book. Candidates may, however, bring two sheets of paper for use as crib sheets. Candidates are permitted to use hand-held calculators.

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

Engineering Design I

Lecturer:
Prof. Dr.-Ing. Robert Lohe, Dipl.-Ing. Carsten Preis, Dipl.-Ing. Guido Wann

Learning objevtives:
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

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

Examinations:
Written Test, 1 hour

Recommended Literature:
1) Lohe, R.: Konstruktionstechnik 1, Vorlesungsbegleittext; Universität Siegen 2001
2) Pahl, G., Beitz, W.: Konstruktionslehre
3) Roth, K.: Konstruieren mit Konstruktionskatalogen
4) Conrad, A., Teufelsdorfer, H.: Kreatives Entwickeln und innovatives Problemlösen mit TRIZ/TIPS

Engineering Design II

Lecturer:
Prof. Dr.-Ing. Robert Lohe, Dipl.-Ing. Carsten Preis, Dipl.-Ing. Guido Wann

Learning objevtives:
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

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

Examinations:
Written Test, 1 hour

Recommended Literature:
1) Lohe, R.: Konstruktionstechnik 2, Vorlesungsbegleittext; Universität Siegen 2001
2) Pahl, G., Beitz, W.: Konstruktionslehre
3) Roth, K.: Konstruieren mit Konstruktionskatalogen

Introduction to Programming

Lecturer:
Prof. Dr. Roland Wismüller

Learning objectives:
The students learn how to write simple computer programs.

Contents:
The course introduces the basic concepts of computer programming, with emphasis on the requirements of engineering students. The course continues after (and assumes the knowledge from) "Introduction to Computer Science", as given in the term before.

The course deals with sequential, imperative, and object-oriented programming, using the C++ programming language. The lecture is accompanied by a series of programming assignments.

Examination:
Students do programming assignments throughout the course.
At the end of the term, a written exam tests the more theoretical aspects of the course.
Programming assignments and written exam contribute 50% each to the overall grade.

Recommended Literature:
J. Liberty. Teach Yourself C++ in 10 Minutes. Sams Publishing, 1999, or:
J. Liberty. Teach Yourself C++ in 10 Minutes. Sams Publishing, second Ed., 2002.

Advanced Control II

Lecturer:
Prof. Dr.-Ing. Hubert Roth

Learning objectives:
Purposes of the course are to

- get used to the z-transformartion and the applications in digital control systems,
- become acquainted with the design of some digital control systems

Contents:

- digital control systems (z-transformation, z-transfer-functions in the control loop, digital controller design)
- optimization of control systems (static/dynamic optimization, lagrange-method, optimization of the parameters and the structure of the control loop, dynamic programming, optimization principle by Bellmann)

Examinations:
Written examination with a duration of 1 hour

Literature:
Gene F. Franklin; J. Davied 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“.

Machine Dynamics & System Dynamics

Lecturer
Prof. Dr.-Ing. Claus-Peter Fritzen

Learning objectives:
Prediction and analysis of the evolution of the system's state, especially in machine and structural dynamics with the motion in terms of displacements, velocities and accelerations as well as dynamic internal forces and moments in machines and structures. The student will also get basic understanding of important vibration phenomena (forced, parametric and self-excited vibrations) and should be able to analyse single and multi degree of freedom systems.

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), 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), Mechatronic Systems and Smart Structures.

Examination:
Written Examination (2 hours)

Recommended Literature:
Ginsberg, J.H., "Advanced Engineering Dynamics", 2nd edition, Cambridge Univ. Press, 1998
Moon, F.C., "Applied Dynamics: With Applications to Multibody and Mechatronic Systems", John Wiley & Sons, 1998
Inman, D.J., "Engineering Vibrations", Prentice Hall, 1994
Ginsberg, J.H., "Mechanical and Structural Vibrations- Theory and Applications", John Wiley, 2001

Sensorics

Lecturer:
Dr.-Ing. habil. Fuad Aliew

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.

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

Examination:
Written Examination (2 hours)

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

Mechatronic Design in Production Machines

Lecturer :
Prof. Dr.-Ing. Armin John

Learning objectives :
Implementation of mechatronic theory in industrial production machines.

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”

Examination: to be agreed.

Recommended Literature: will be published during the lecture.

Project Management II

Lecturer:
Prof. Dr.-techn. Gerald Adlbrecht

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.

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

Examinations:
There is one written Final Exam at the end of lecture period.

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.

Actorics

Lecturer:
Prof. Dr.-Ing. J. Mario Pacas

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 alectronics is in the main focius of the course.

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.

Examinations:
Oral examination

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 Hall

Modelling and Simulation

Lecturer:
Prof. Dr. Wolfgang Wiechert

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 circiuits, 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.

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. Course of a simulation study
2. Typical time continuous simulation tools
3. Basic concepts of stochastic simulation
4. Discrete event simulation
5. Numerical solution of ordinary differential equations
6. Treatment of stationary and quasi-stationary systems
7. Stiff and differential algebraic equations

8. Application domains of simulation

Optional courses on “Modeling and Simulation 3-6” are concerned with special aspects of simulation:

M&S 3: Multidisciplinary Modeling
M&S 4: Dynamic Systems Analysis
M&S 5: Regression and Experimental Design
M&S 6: Stochastic Simulation

More details can be found in the brochure “Vorlesungsführer Simulationstechnik” available at the secretary of the simulation group (Prof. Wiechert).

Examination:
Written exam (2 hours) for “Modeling and Simulation 1&2” for mechatronics students.

Recommended Literature:
The following material is available on the internet. See “Materialien” on www.simtec.mb.uni-siegen.de :

1. Skriptum of all lectures (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.)

S/W Engineering

Lecturer:
Dr.-Ing. Frank Katritzke

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)

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

Examination:
Students do programming assignments throughout the course. In the second half of the course, they realize a small project in groups of about 6 persons.

Recommended Literature:

uml_tutorial.pdf
http://www.omg.org/technology/documents/modeling_spec_catalog.htm

Mechatronic Systems

Lecturer:
Prof. Dr.-Ing. Hubert Roth

Learning objectives:
Purposes of the course are to

- design and analyse mechatronic systems as a optimal combination of mechanical, electrical and software components.
- demonstrate the advantage of machatronic systems in different application areas.
- get experience with mechatronic systems by performing different laboratory experiments

Contents:

- Characteristics of mechatronic systems
- Sensor and actuator for mechatronic systems
- Modelling
- Identification
- Control concepts for mechatronics systems
- Typical examples of integrated mechanical – electrical systems

Examination:
Written examination with a duration of 3 hours.

Recommended Literature:
R. Isermann: Mechatronische Systeme. Springer Verlag, 1999.
Schilling: Fundamentals of Robotics, Prentice Hall.
Craig: Robotics, Addison Wesley.

Control Laboratory

Lecturer:
Prof. Dr.-Ing. Hubert Roth, Prof. Dr.-Ing. Robert Mayr,
Dipl.-Ing. Martin Rühl, Dipl.-Ing. Oleg Bauer

Learning objectives:
Purposes of the laboratory are to

- Realize and understand the control structures given in the lectures
- Install control algorithms to real systems and test closed loop dynamics
- Learn the fundamentals of Matlab for simulation of real systems

Contents:
The laboratory contains the following experiments:

- Basics of Matlab/Simulink
- Decoupling of control systems
- State space controller in Matlab
- Digital Control of a DC motor
- Dead-Beat controller of a helicopter experiment
- Optimization of control systems in Matlab

Examination:
Oral test at each experiment

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

Optional Subjects

Additional optional courses which are taught in English can be selected from technical and non-technical subjects offered by other faculties of the University.