Technische Hochschule Ingolstadt

Programme and Course Description

International Automotive Engineering

Master

Faculty of Electrical Engineering and Computer Science

As per: 2018-01-23

Content

1 Introduction

The program takes three semesters. The first two semesters are dedicated to lectures, seminars and projects. The third semester is reserved for the Master's thesis. The curriculum of the Master's program has been tailored towards the intermediation of expertise that is required to work on problems in development of electronic systems in automobiles. It mediates the special of the engineer-scientific approach. It explains the means of language and symbols to be used in automobile projects. However, scientific oriented work in a master program means that students learn independently and solely responsible.

Multi-disciplinary modules structure the program. The subjects of the modules emanate from mechanical engineering, electrical engineering, mathematics and engineering methodology.

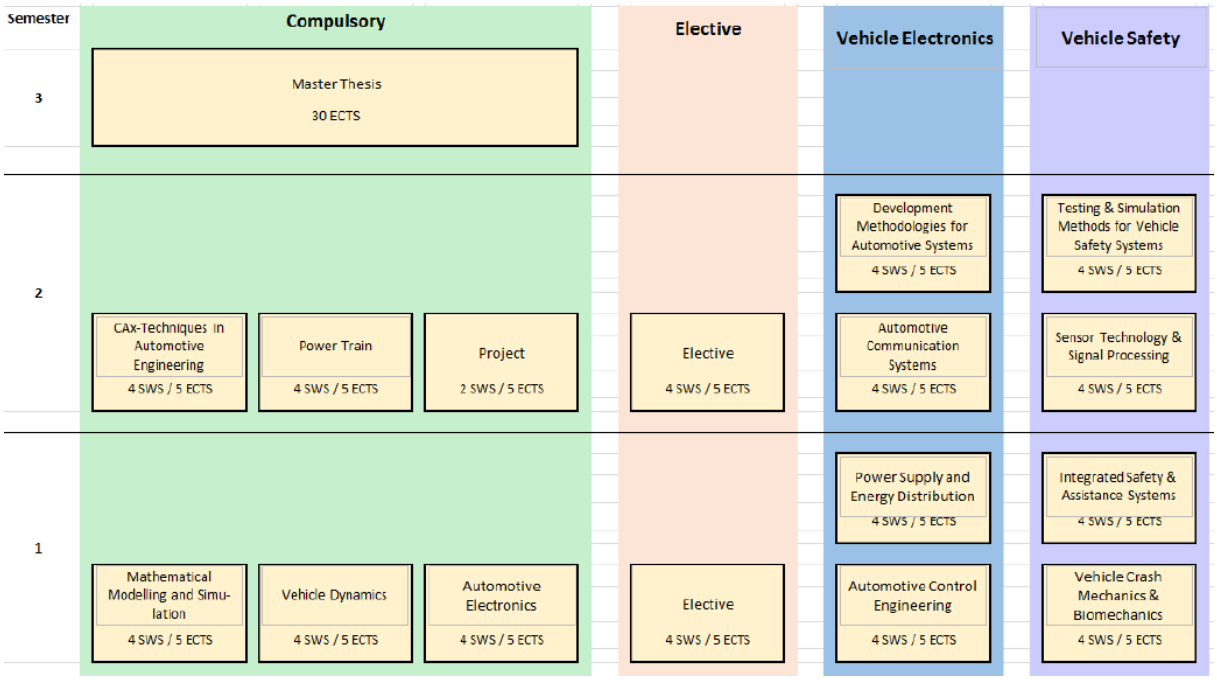

Figure 1: Program structure

Compulsory modules aim at transfer of knowledge an automotive engineer must have. The compulsory module Project enables students to incorporate into a new to complex task and - based on a division of labor - to work on this task interdisciplinary in a team using suitable scientific methods.

Out of two core areas, one has to be selected:

- vehicle electronics

  The modules will equip students with fundamentals of the systematically development of cooperating electronic systems, and will prepare them for real world applications

- vehicle safety

  The modules will prepare students for the design, construction and test of systems that minimize the occurrence and consequences of vehicle collisions

Elective modules allows for an individual specialization.

The master's thesis is a practice-oriented research project on an elective topic subject to approval by the student's supervisor. The thesis is written under the guidance of one professor from University of Applied Sciences Ingolstadt (first supervisor).

2 Description of Modules

2.1 Compulsory Modules

Mathematical Modeling and Simulation			
Module abbreviation:	IAE_MMS	**Reg.no.:**	1
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Hagerer, Andreas	
Language of instruction:	English	
Credit points / SWS:	5 ECTS / 4 SWS	
Workload:	Contact hours:	47 h
	Self-study:	78 h
	Total:	125 h
Subjects of the module:	1 Mathematical Modeling and Simulation (IAE_MMS)	
Lecture types:	IAE_MMS: SU/Ü - lecture with integrated exercises	
Examinations:	1 schrP90 - written exam, 90 minutes	

Prerequisites according examination regulation:

None

Recommended prerequisites:

Engineering mathematics; Relationships between describing variables (force, torque, current, ...) of the mechanical and electrical energy domain

Objectives:

After successfully completing the module, students

- understand the process of system modelling
- are able to formulate mathematical models of physical systems by means of input/output equations
- are able to model systems of different energy domains in state space representation according to unified approaches
- are able to use software tools (e.g. Matlab/Simulink) for modelling, simulation, and analysis

Content:

The following topics are covered:

- continuous time modelling of mechanical, electrical, and hybrid systems by means of linear graphs and bond graphs
- event discrete modelling by means of Stateflow
- tools: solution of dynamic problems using a digital simulation packages for continuous time/sampled data systems such as MATLAB/Simulink

Literature:

Compulsory:

None

Recommended:

- SEELER, Karl A., 2014. *System dynamics: an introduction for mechanical engineers* [online]. New York, NY [u.a.]: Springer PDF e-Book. ISBN 978-1-4614-9152-1, 978-1-4614-9151-4. Available via: http://dx.doi.org/10.1007/978-1-4614-9152-1.
- BROWN, Forbes T., 2007. *Engineering system dynamics: a unified graph-centered approach*. 2. edition. Boca Raton, FL [u.a.]: CRC, Taylor & Francis. ISBN 978-0-8493-9648-9, 0-8493-9648-4
- KARNOPP, Dean C., MARGOLIS, Donald L., ROSENBERG, Ronald C., 2012. *System dynamics: modeling, simulation, and control of mechatronic systemsc* [online]. Hoboken, NJ: Wiley PDF e-Book. ISBN 978-1-118-15281-2, 978-0-470-88908-4. Available via: http://dx.doi.org/10.1002/9781118152812.
- KARRIS, Steven T., 2007. *Introduction to Stateflow with applications*. [Fremont, CA]: Orchard Publ.. ISBN 978-1-934404-07-2, 1-934404-07-1

CAx-Techniques in Automotive Engineering

Module abbreviation:	IAE_CAX	**Reg.no.:**	2
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Elger, Gordon
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	2 CAx-Techniques in Automotive Engineering (IAE_CAX)
Lecture types:	IAE_CAX: SU/Ü - lecture with integrated exercises
Examinations:	2 prA - practical assignment Practical assignment: CAD integrated FE or CFD Simulation project which is concluded by a report and an oral examination in front of the computer explaining the simulation (assumptions, pre and post processing, results)

Prerequisites according examination regulation:

None

Recommended prerequisites:

Differential equations: formulation and solving methods; basic knowledge about Finite Element Methode; practical experiences with computer aided engineering software

Objectives:

After successfully completing the module students have the following expertise:

- Understanding of simulation driven design and virtual prototyping in the context of Computer Aided X (X=Design, Engineering, Manufacturing, Quality, ...)
- Ability to realize hands-on basic parametric CAD design and configuration management to be able to run CAD integrated FEA (finite element analysis)
- Ability to apply FEA to engineering problems, especially to stress, modal, thermo-mechanical and thermal analysis
- Ability to solve problems in this field, e.g. verification, validation and calibration of FE models
- Ability to formulate simulation tasks, run FE simulation, document and report results

Content:

- Overview of CAx workflow in context of modern PLM (Product lifecycle management) in the automotive industry
- Simulation driven design and CAD integrated simulation: approach, workflow, advantage, challenges
- Basics of associative and parametric CAD design
- Outline of the basic concept of FEM
  - Differential equation and boundary conditions
  - Introduction in FEM, FDM,FVM,
  - The principle of virtual work; Typical Finite Elements
  - Steps of a Finite Element Analysis (FEA), classification of FE solver

- Finite Element formulation for structural analysis
  - Stiffness matrix
  - Linear and nonlinear analysis, modal analysis, dynamic analysis, crash test
- Thermal analysis: heat transfer and thermal boundary condition
- Basics of computational fluid dynamics

Literature:

Compulsory:

- KUROWSKI, Paul M., 2014. *Thermal analysis with SolidWorks simulation 2014*. Mission, Kan.: SDC Publ.. ISBN 978-1-58503-862-6, 1-58503-862-8
- KUROWSKI, Paul M., 2014. *Engineering analysis with SolidWorks simulation 2014*. Mission, Kan.: SDC Publ.. ISBN 978-1-58503-858-9, 1-58503-858-X

Recommended:

- GOHALE, Nitin S and ET AL., 2008. *Practical Finite Element Analysis*. Maharashtra, India: Finite to Infinite.
- UM, Dugan, 2016. *Solid modeling and applications: rapid prototyping, CAD and CAE theory* [online]. Cham: Springer International Publishing PDF e-Book. ISBN 978-3-319-21822-9, 978-3-319-21821-2. Available via: http://dx.doi.org/10.1007/978-3-319-21822-9.

Power Train

Module abbreviation:	IAE_PT	**Reg.no.:**	3
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Schiele, Thomas
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	3 Power Train (IAE_PT)
Lecture types:	IAE_PT: SU/Ü - lecture with integrated exercises
Examinations:	3 schrP90 - written exam, 90 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

basic knowledge of physics (Work, Power, Forces, Torques, ...), engineering mathematics (differential and integral calculus), engineering mechanics

Objectives:

After successfully completing the module the students

- know details about legal framework conditions for current and future powertrain developments (CO2- and emission legislation, test procedures, test cycles, ...)
- understand advantages and disadvantages of different drivetrain concepts according to driving performance and energy consumption
- show detailed knowledge of internal combustion engine design principles and operation strategies
- are able to explain the operating principles of different gearbox constructions and know advantages and disadvantages of the different concepts
- have a detailed understanding of hybrid drivetrain architectures and know about the potentials of hybrid drivetrain technology
- know different energy storage systems for vehicle applications and their advantages and disadvantages

Content:

- basics of vehicle movement and driving resistances
- market-specific test procedures for series-production vehicles / certification
- design principles of internal combustion engines (ICE)
- advantages/disadvantages of different IC-engine concepts (diesel/gasoline, ...)
- concepts for fuel consumption reduction in modern IC-engines
- emission generation in IC-engines / exhaust gas aftertreatment
- gearbox concepts and start-up elements
- hybrid and electric drivetrain concepts
- potentials of electrified drivetrains according to fuel consumption and emission generation
- energy storage systems for vehicle applications

Literature:

Compulsory:

None

Recommended:

- MASHADI, Behrooz, CROLLA, David, 2012. *Vehicle powertrain systems* [online]. Chichester: Wiley PDF e-Book. ISBN 978-0-470-66602-9, 978-1-11-995836-9. Available via: http://onlinelibrary.wiley.com/book/10.1002/9781119958376.
- TODSEN, Uwe, 2012. *Verbrennungsmotoren* [online]. München: Hanser PDF e-Book. ISBN 978-3-446-42846-1, 978-3-446-41843-1. Available via: http://www.hanser-elibrary.com/action/showBook?doi=10.3139%2F9783446428461.
- KLEMENT, Werner, 2011. *Fahrzeuggetriebe* [online]. München: Hanser PDF e-Book. ISBN 978-3-446-42807-2, 978-3-446-42600-9. Available via: http://www.hanser-elibrary.com/action/showBook?doi=10.3139%2F9783446428072.
- HOFMANN, Peter, 2014. *Hybridfahrzeuge: ein alternatives Antriebskonzept für die Zukunft* [online]. Wien [u.a.]: Springer PDF e-Book. ISBN 978-3-7091-1780-4. Available via: http://dx.doi.org/10.1007/978-3-7091-1780-4.

Vehicle Dynamics

Module abbreviation:	IAE_VDS	**Reg.no.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Arnold, Armin
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	4 Vehicle Dynamics (IAE_VDS)
Lecture types:	IAE_VDS: SU/Ü - lecture with integrated exercises
Examinations:	4 schrP90 - written exam, 90 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

ability to apply the physical rules of mechanical systems, especially Newton's laws; basic knowledge of electrics/electronics

Objectives:

After successfully completing the module the students shall be able to

- explain and judge all tire properties that are important for vehicle dynamics
- calculate according to some simplified vehicle models
- analyse how drivetrain, brakes and other chassis components work together, e.g. like control arms, spring rates, position of center of gravity, differentials including limited slip differentials, torque-vectoring-differentials
- explain ABS-control
- explain vehicle stability control systems
- deduct the additional possibilities given by four-wheel-steering, torque-vectoring and active suspensions

Content:

- Tire and tire properties under different conditions (camber, normal force, combinations of longitudinal and/or lateral slip, Kamm's circle and its application)
- Vehicle models (Single track model, dual track model)
- Influencing driving behaviour by::
  - Suspension:: Roll- und instant center, (elasto)-kinematics
  - Spring stiffnesses
  - position of center of gravity
  - Distribution of driving- and braking torques
- ABS
- vehicle stability control
- torque vectoring

Literature:

Compulsory:

None

Recommended:

- REIMPELL, Jörnsen, Jürgen W. BETZLER and Helmut STOLL, 2001. *The automotive chassis: engineering principles: chassis and vehicle overall, wheel suspensions and types of drive, axle kinematics and elasto-kinematics, steering - springing - tyres, construction and calculations advice*. 2. edition. Oxford [u.a.]: Butterworth-Heinemann. ISBN 0-7506-5054-0
- MILLIKEN, William F. and Douglas L. MILLIKEN, 1995. *Race car vehicle dynamics*. Warrendale, PA: SAE International. ISBN 1-56091-526-9, 978-1-56091-526-3
- GENTA, Giancarlo and Lorenzo MORELLO, . *The automotive chassis*. [Dordrecht]: Springer Netherland.
- HANEY, Paul, 2012. *The racing & high-performance tire: using the tires to tune for grip and balance*. 3. edition. Dallas, Tex. [u.a.]: InfoTire [u.a.]. ISBN 0-9646414-2-9, 978-0-7680-12415

Automotive Electronics

Module abbreviation:	IAE_AES	**Reg.no.:**	5
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Birkner, Christian
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	5 Automotive Electronics (IAE_AES)
Lecture types:	IAE_AES: SU/Ü - lecture with integrated exercises
Examinations:	5 schrP90 - written exam, 90 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

Electrics/electronics basic course; bachelor course in technical mathematics (Fourrier, Laplace, ...); bachelor course in physics; bachelor course in technical mechanics; Matlab/Simulink

Objectives:

After successfully completing the module, the students have a

- knowledge of the architecture of automotive control units and applied integrated circuits
- comprehension of the functional dependencies
- ability to apply the knowledge to specify and design control units
- ability to analyse control units on the level of electric signals, ability for basic analysis on electromagnetic field level

Content:

- basics of electrical and electronic engineering
- recapitulation of microcontroller technology
- control unit circuits for input and sensor signal conditioning, output drivers and controlling actuators, power supply
- physical layer of automotive communication networks and onboard communication
- basic problems of electromagnetic emission and immunity of control units
- introduction to automotive electric standards

Literature:

Compulsory:

None

Recommended:

- ZAMAN, Najamuz, 2015. *Automotive electronics design fundamentals* [online]. Cham [u.a.]: Springer PDF e-Book. ISBN 978-3-319-17584-3, 978-3-319-17583-6. Available via: http://dx.doi.org/10.1007/978-3-319-17584-3.

- IDA, Nathan, 2015. *Engineering electromagnetics* [online]. Cham [u.a.]: Springer PDF e-Book. ISBN 978-3-319-07806-9, 978-3-319-07805-2. Available via: http://dx.doi.org/10.1007/978-3-319-07806-9.
- ROBERT BOSCH GMBH (ED.), , 2014. *Bosch Automotive Electrics and Automotive Electronics: Systems and Components, Networking and Hybrid Drive* [online]. PDF e-Book. ISBN 978-3-658-01784-2. Available via: http://dx.doi.org/10.1007/978-3-658-01784-2.

Group Project

Module abbreviation:	IAE_PRJ	Reg.no.:	6
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	2

Responsible for module:	Hagerer, Andreas
Language of instruction:	English
Credit points / SWS:	5 ECTS / 2 SWS
Workload:	Contact hours: 24 h Self-study: 101 h Total: 125 h
Subjects of the module:	6 Group Project (IAE_PRJ)
Lecture types:	IAE_PRJ: Prj - project
Examinations:	6 LN - project work

Prerequisites according examination regulation:

None

Recommended prerequisites:

Knowledge mediated in IAE-lectures of first semester

Objectives:

The project conduces to the development of interdisciplinary interrelations and the development of methods and social competence. This compromises the development of alternatives from literature and/or lectures, which solve a given problem, the development of a solution approach, and the representation in a project report. At the same time the project serves gaining experiences in the organization of team processes and techniques of moderation and presentation.

Content:

Topics of the projects offered in this term are:

- Short Circuit (Fort Prinz Karl Test Bench) (Steger, Fabian)
  Aim of this project is to create a test bench for short circuit tests on lithium ion cells and cell stacks. The students are asked to build a customized version of a remote controlled switch/circuit breaker, doing the mechanical design, the construction and the assembly of all the parts. The bench will be a flexible construction for research purpose. All the parts should be easily dismountable/to clean and weighting less than 15 kg. The electrical resistance should be below of five milliohm. The device should close and open the circuit remote controlled. Safety of the research personal has be taken in account.
- Analysis of parameters of safety critical turning scenarios at intersections (Huber, Werner)
  The project shall identify relevant parameters describing turning-off- like typical car trajectories, pedestrian and bicyclist movements scenarios at different types of intersections. Based on the results, the sensor parameters for detecting the mentioned objects above have to be derived.

Literature:

Literature is given in the course depending on the topic of the project.

Master´s Thesis

Module abbreviation:	IAE_THESIS	**Reg.no.:**	10
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	

Responsible for module:	Hagerer, Andreas
Language of instruction:	German
Credit points / SWS:	30 ECTS / 1 SWS
Workload:	Contact hours: 12 h Self-study: 738 h Total: 750 h
Subjects of the module:	10 Master´s Thesis (IAE_THESIS)
Lecture types:	IAE_THESIS:
Examinations:	10 Master-Thesis Registration for the thesis is required. It can be done online anytime.

Prerequisites according examination regulation:

Acquirement of 30 ECTS in form of completed modules.

Recommended prerequisites:

All theory modules should have been attended and successfully completed, at least those which are closely related to the area of the thesis' topic.

Objectives:

The master's thesis will demonstrate that the candidate is able to scientifically work on a current research topic work in the field within a specified time frame, with an increasing degree of independence applying scientific methods; investigate a problem, organize and logically present data, draw defensible conclusions, develop a solution or make recommendations, and present the results in a scientifically appropriate form.

Objective of the seminar consists in accompanying and supporting the progress of the thesis.

Content:

The Master thesis is a self study aimed at deepening a student's understanding of a selected key subject area in automotive engineering. The work should have elements of research (new knowledge or methods). Normally a pre-study is performed. The pre-study may be literature search, introductory investigations or state of the art surveys.

The report must comprise a description of the problem, the results and the work. Prototypes or products developed as part of the work may be included as part of the thesis.

The seminar is closely and indivudally related to subject and approaches of the student's thesis. Both will be presented, defended and discussed.

Literature:

Own research, depending on the subject of work.

Seminar for Master's thesis

Module abbreviation:		**Reg.no.:**	11
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory subject	3

Responsible for module:	Hagerer, Andreas
Language of instruction:	English
Credit points / SWS:	0 ECTS / 1 SWS
Workload:	Contact hours: 12 h Self-study: -12 h Total: 24 h
Subjects of the module:	11 Seminar for Master's thesis () (IAE_MTSEM_BIB1) (IAE_MTSEM_BIB2)
Lecture types:	
Examinations:	

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

Students are able

- to use the resources providing information for retrieval and access to scientific literature
- to search for high-quality scientific information systematically and object-oriented
- have a basic understanding of strategy and methodology of researching information for scientific papers
- to search for scientific information and techniques of scientific work
- learn the steps necessary to create a scientific work
- act responsibly with information: they can quote scientifically correct, create a bibliography for a research paper and interpret references

Content:

- get to know the library and its offers
- basic knowledge of search strategy
- important library catalogues, scientific databases and other sources
- evaluation of information sources
- plagiarism
- scientific work: quote
- reference management

Literature:

Compulsory:

- FRANKE, Fabian, 2014. *Schlüsselkompetenzen: Literatur recherchieren in Bibliotheken und Internet* . 2. edition. Stuttgart: Metzler. ISBN 978-3-476-02520-3 ; 3-476-02520-9

Recommended:

None

2.2 Compulsories of the Core Area "Vehicle Electronics"

Automotive Control Engineering			
Module abbreviation:	IAE_ACE	**Reg.no.:**	7.1.1
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Gregor, Rudolf
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.1.1 Automotive Control Engineering (IAE_ACE)
Lecture types:	IAE_ACE: SU/Ü - lecture with integrated exercises
Examinations:	7.1.1 schrP90 - written exam, 90 minutes

Prerequisites according examination regulation:

Keine

Recommended prerequisites:

Good knowledge of classical control engineering methods

Objectives:

After successfully completing the module students are able to

- analyze and describe systems in time and frequency domain
- select and design controllers based on classical control engineering methods (root locus, bode diagram)
- model and analyze LTI-systems in state space
- design state space controllers for SISO and MIMO-systems using different methods
- design observers for LTI-systems
- solve simple control tasks for non-linear systems

Content:

- Repetition of classical control engineering methods
- State space representation of linear time invariant systems
- Analysis of system properties (dynamics, stability, controllability, observability) in state space
- Design of state feedback and feedforward control (pole placement, modal control, optimal control)
- Design of state observers
- Representation and analysis of non-linear control systems
- Lab work: Design and test of different types of control systems by use of Matlab-Simulink

Literature:

Compulsory:

None

Recommended:

- BOLTON, William, 2010. *Control engineering*. 2. edition. Harlow u.a.: Prentice Hall. ISBN 978-0-582-32773-3
- BURNS, Roland S., 2001. *Advanced control engineering*. Oxford: Butterworth-Heinemann. ISBN 978-0-7506-5100-4, 0-7506-5100-8
- FRANKLIN, Gene F., J. David POWELL and Abbas EMAMI-NAEINI, 2015. *Feedback control of dynamic systems*. 7. edition. Upper Saddle River, NJ [u.a.]: Pearson. ISBN 978-1-29-206890-9, 1-29-206890-6
- DORF, Richard C. and Robert H. BISHOP, 2014. *Modern control systems*. 12. edition. Harlow [u.a.]: Pearson. ISBN 978-1-29202-405-9, 1-292-02405-4
- OGATA, Katsuhiko, 2010. *Modern control engineering*. 5. edition. Boston [u.a.]: Pearson. ISBN 978-0-13-713337-6, 0-13-713337-5

Power Supply and Energy Distribution

Module abbreviation:	IAE_PSED	**Reg.no.:**	7.1.2
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Pforr, Johannes
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.1.2 Power Supply and Energy Distribution (IAE_PSED)
Lecture types:	IAE_PSED: SU/Ü - lecture with integrated exercises
Examinations:	7.1.2 schrP90 - written exam, 90 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

Basic knowledge of electronics

Objectives:

After successfully completing the module the students should

- have good knowledge in the field of modern energy distribution systems in cars and of the components used in the automotive energy nets
- understand why energy management systems are important for the operation of electric energy nets in cars
- understand the operation principle of power electronic converters for automotive applications
- understand and to use methods to develop steady-state and dynamic models of power electronic converters for given type of problems
- analyze and judge the steady-state and dynamic performance of automotive electrical energy nets with power electronic components according to given targets
- understand the operation principle of modern electric machines for electric and hybrid electric vehicles including the control of the electric machines
- be able to use steady-state and dynamic models of electric machines in order to analyze the energy flow in automobile electrical energy nets dependent on the operation strategy of the vehicle
- be able to derive models of given automotive energy nets and the components and to perform simulations for optimization purposes

Content:

- Power Devices and Converter Topologies
- 14V / 48V Power Supply and Energy Distribution
- Generation of electric Power in Vehicles
- Energy management Systems
- High Voltage electric Energy Distribution for Hybrid Vehicles
- Electric motor Drives and motion Control

- Starter / Generator
- Simulation

Literature:

Compulsory:

None

Recommended:

- VELTMAN, Andre, PULLE, Duco W.J., DE DONCKER, Rik W., 2016. *Fundamentals of Electrical Drives* [online]. PDF e-Book. ISBN 978-3-319-29409-4, 978-3-319-29408-7. Available via: http://dx.doi.org/10.1007/978-3-319-29409-4.
- ERICKSON, Robert W. and Dragan MAKSIMOVIĆ, 2004. *Fundamentals of power electronics*. 2. edition. Dordrecht: Kluwer. ISBN 0-7923-7270-0, 978-0-7923-7270-7
- LEONHARD, Werner, 2001. *Control of electrical drives*. 3. edition. Berlin [u.a.]: Springer. ISBN 3-540-41820-2
- EHSANI, Mehrdad, Yimin GAO and Ali EMADI, 2010. *Modern electric, hybrid electric, and fuel cell vehicles: fundamentals, theory, and design*. 2. edition. Boca Raton, FL [u.a.]: CRC Press, Taylor & Francis Group. ISBN 978-1-4200-5400-2, 978-1-4200-5398-2

Automotive Communication Systems

Module abbreviation:	IAE_ACS	**Reg.no.:**	7.1.3
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Frey, Andreas (Prof.)
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.1.3 Automotive Communication Systems (IAE_ACS)
Lecture types:	IAE_ACS: SU/Ü - lecture with integrated exercises
Examinations:	7.1.3 schrP120 - written exam, 120 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

- basic knowledge in Informatics and in Software Development; Data Formats binary, decimal, hexadecimal

Objectives:

After successfully completing the module, the students

- know systems and procedures to distribute information in between the vehicle systems.
- know wired and wireless bus systems and their characteristics.
- are able to analyze requirements for the vehicle onbord and offboard communication and to specify a communication concept fulfilling the requirements.
- are able to understand complex communication problems and to solve those problems choosing the most critical information, logical reasoning and raising the appropriate questions.
- are able to develop own ideas and are able to apply scientific concepts to solve applied development tasks.

Content:

- Introduction to
  - OSI layer model, Communication Interfaces to Embedded Operating Systems
  - network descriptive structures, network functionality, network technologies
  - protocols
- Characteristics and discussion of current bus systems
  - LIN, CAN, Flexray, MOST
  - Ethernet with real time protocol
  - Wireless Networks WLAN
  - Methods to analyze the bus communication
- Mechanisms to secure the data connection
- High Level network protocols for diagnostics KWP2000 and ISO14229

Literature:

Compulsory:

None

Recommended:

- PARET, Dominique and Roderick RIESCO, 2007. *Multiplexed networks for embedded systems: CAN, LIN, Flexray, Safe-by-Wire ...* Chichester: Wiley. ISBN 0-470-03416-5, 978-0-470-03416-3
- SMITH, Craig, 2016. *The car hacker's handbook: a guide for the penetration tester*. San Francisco, CA: No Starch Press. ISBN 978-1-59327-703-1

Development Methodologies for Automotive Systems

Module abbreviation:	IAE_DMAS	**Reg.no.:**	7.1.4
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Margull, Ulrich
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.1.4 Development Methodologies for Automotive Systems (IAE_DMAS)
Lecture types:	IAE_DMAS: SU/Ü - lecture with integrated exercises
Examinations:	7.1.4 LN - oral exam, 20 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

basic programming skills, preferably in the area of C language; basic understanding of computer architecture and software engineering

Objectives:

After successful completion of this module, the students

- will understand the basics of the E/E development process in the Automotive Industry.
- will be able to develop and design software for embedded, automotive, real-time systems using AUTOSAR.
- will have a basic understanding of the overall software development process for automotive systems.

Content:

- Introduction: automotive systems
- Automotive microcontrollers: architecture, memory
- Fundamentals of microcontroller programming: structure of automotive software, memory mapping, efficient and portable programming, MISRA C programming guidelines
- Architecture of automotive software: modularity, software layers, real-time systems (tasks, scheduling), resource management (deadlocks, semaphores, priority inversion), interrupts and timers
- Software processes: V-model and MISRA development guideline, process assessment (CMMI, automotive SPICE), model-based development (Matlab/Simulink/Stateflow)
- Safety: IEC 61508 and WD 26262, safety measures (self test, redundancy, COP, diagnostics)
- AUTOSAR development process, AUTOSAR architecture: Virtual Function Bus, Application Components, RTE, BSW, AUTOSAR OS

Literature:

Compulsory:

None

Recommended:

- MARWEDEL, Peter, 2011. *Embedded system design: embedded systems foundations of cyber-physical systems* [online]. Dordrecht [u.a.]: Springer PDF e-Book. ISBN 978-94-007-0257-8, 978-94-007-0256-1. Available via: http://dx.doi.org/10.1007/978-94-007-0257-8.
- LEE, Edward Ashford and Sanjit Arunkumar SESHIA, 2012. *Introduction to embedded systems: a cyber-physical systems approach*. 1. edition. [s.l.]: LeeSeshia.org. ISBN 978-0-557-70857-4
- Without author, 2016. *AUTOSAR* [online]. , 10.6.2016 [Accessed on: 10.6.2016]. Available via: autosar.org
- SCHAUFFELE, Jörg, 2005. *Automotive Software Engineering*. 1. edition. ISBN 978-0768014907

2.3 Compulsories of the Core Area "Vehicle Safety"

Vehicle Crash Mechanics and Biomechanics			
Module abbreviation:	IAE_VCM	**Reg.no.:**	7.2.1
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Brandmeier, Thomas
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.2.1 Vehicle Crash Mechanics and Biomechanics (IAE_VCM)
Lecture types:	IAE_VCM: SU/Ü - lecture with integrated exercises
Examinations:	7.2.1 schrP90 - written exam, 90 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

knowledge of basics in mechanics, in electrics/electronics, of communication systems and of vehicle electronics

Objectives:

After successfully completing the module, students know the basic concepts and knowledge in vehicle safety and crash mechanics. The program is structured to cover the important topics related to the vehicle safety: Crash modelling for frontal and lateral collisions and rollovers, finite element analysis, occupant protection strategies, Passive vehicle safety systems (airbag control unit, conventional crash sensors, algorithms, safety actuators) and biomechanics. At the completion of this course, students should be able to understand crash processes, to construct and simulate simple crash models, understand human anatomy and its mechanics during vehicle crash.

Content:

The following topics are covered:

- Basic terms and definitions in vehicle safety
- Crash Mechanics
- Crash Modelling, Multibody Modelling, Finite Element Analysis
- Passive Safety Systems
- Frontal and lateral collision, Rollover
- Crash- & Safety-Sensors, Crash detection Algorithms, Use of environmental sensors in Passive Safety
- Irreversible and reversible Safety Actuators
- Emergency Medicine
- Biomechanics

Literature:

Compulsory:

None

Recommended:

- HUANG, Matthew, 2002. *Vehicle crash mechanics*. Boca Raton [u.a.]: CRC Press. ISBN 0-8493-0104-1
- WINNER, Hermann, HAKULI, Stephan, LOTZ, Felix, 2016. *Handbook of driver assistance systems* [online]. *Basic Information, Components and Systems for Active Safety and Comfort*. PDF e-Book. ISBN 978-3-319-12352-3.
- BOSCH, Robert GmbH (Hrsg.), 2014. *Automotive Handbook*. 9. edition. ISBN 1119032946

Integrated Safety and Assistance Systems

Module abbreviation:	IAE_ISAS	**Reg.no.:**	7.2.2
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Botsch, Michael
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.2.2 Integrated Safety and Assistance Systems (IAE_ISAS)
Lecture types:	IAE_ISAS: SU/Ü - lecture with integrated exercises
Examinations:	7.2.2 schrP90 - written exam, 90 minutes

Prerequisites according examination regulation:

Mathematics for Engineers

Recommended prerequisites:

Basics of Vehicle Dynamics; Basics of Signal Processing; Basics of Control Theory; Basics Matlab

Objectives:

After successfully completing the module the students are able

- to explain basic vehicle components that are required for driver assistance systems and for vehicle integrated safety functions;
- to analyze and evaluate state of the art driver assistance systems;
- to describe testing procedures that are used for vehicle active safety functions;
- to explain mathematically the concepts for motion planning that are used in algorithms for driver assistance systems and integrated safety functions;
- to implement basic trajectory planning algorithms in Matlab.

Content:

- Introduction to IS & DAS
- Examples of Driver Assistance and Integrated Vehicle Safety Systems: Parking Systems, Adaptive Cruise Control, Autonomous Emergency Braking
- Position and Orientation: Pose, Representing Pose in 2-D and in 3-D
- Time and Motion: Generation of Trajectories, Rate of Change and Inverse Problem
- Vehicle Motion Models: Decoupled X- and Y-Dynamics, Constant Velocity Model
  - Constant Steering Angle and Velocity Model, Constant Turn Rate and Acceleration Model, One-Track Model, Two-Track Model
- Navigation and Localization

Literature:

Compulsory:

None

Recommended:

- KELLY, Alonzo, 2013. *Mobile robotics: mathematics, models, and methods*. 1. edition. New York, NY: Cambrige Univ. Press. ISBN 978-1-107-03115-9
- HEIßING, Bernd, 2011. *Chassis handbook: fundamentals, driving dynamics, components, mechatronics, perspectives* [online]. Wiesbaden: Vieweg+Teubner PDF e-Book. ISBN 978-3-8348-9789-3, 978-3-8348-0994-0. Available via: http://dx.doi.org/10.1007/978-3-8348-9789-3.
- WINNER, Hermann, HAKULI, Stephan, LOTZ, Felix, SINGER, Christina, 2016. *Handbook of driver assistance systems: basic information, components and systems for active safety and comfort* [online]. [Cham]: Springer International Publishing PDF e-Book. ISBN 978-3-319-12352-3, 978-3-319-12351-6. Available via: http://dx.doi.org/10.1007/978-3-319-12352-3.

Sensor Technology and Signal Processing

Module abbreviation:	IAE_ST&SP	**Reg.no.:**	7.2.3
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Botsch, Michael
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.2.3 Sensor Technology and Signal Processing (IAE_ST&SP)
Lecture types:	IAE_ST&SP: SU/Ü - lecture with integrated exercises
Examinations:	7.2.3 schrP90 - written exam, 90 minutes Prerequisites: • Linear algebra • Probability theory • Basics of signal processing

Prerequisites according examination regulation:

Mathematics for Engineers

Recommended prerequisites:

Basics of Signal Processing; Basics of Control Theory; Basics Matlab

Objectives:

After successfully completing the module the students are able to

- describe major trends in the automotive sensor market;
- categorize automotive sensors with respect to the underlying physical effects;
- to analyze sensor signals in the time- and frequency-domain;
- apply statistical signal processing algorithms (e. g., Kalman filter) to automotive sensor data;
- to evaluate algorithms for sensor data fusion;
- to design and apply simple machine learning algorithms
- to implement statistical signal processing algorithms in Matlab.

Content:

- Introduction to Automotive Sensors
  - Automotive Sensor Market
  - Sensor Technologies
  - Sensor Types and Characteristics
  - Multi-Modal Sensor Systems
- Statistical Signal Processing
  - Signal Types and Characteristics
  - Basics of Statistical Signal Processing
  - Pattern Recognition

- Kalman Filter
- Sensor Data Fusion
  - Data Association
  - Track-To-Track Fusion
- Analog and Digital Processing of Signals
  - Analog Filters, Amplifiers and A/D Converters
  - Fourier Series and Transform, Laplace- and z-Transform
  - Digital Filters

Literature:

Compulsory:

None

Recommended:

- MAREK, Jiří, 2005. *Sensors for automotive applications* [online]. Weinheim: Wiley-VCH PDF e-Book. ISBN 3-527-60142-2, 3-527-29553-4. Available via: http://dx.doi.org/10.1002/3527601422.
- LATHI, Bhagawandas P., 2010. *Signal processing and linear systems*. I. edition. Oxford: Oxford Univ. Press. ISBN 978-0-19-539257-9
- HASTIE, Trevor, Robert TIBSHIRANI and Jerome H. FRIEDMAN, 2013. *The elements of statistical learning: data mining, inference, and prediction*. 2. edition. New York [u.a.]: Springer. ISBN 978-0-387-84857-0, 978-0-387-84858-7
- BAR-SHALOM, Yaakov, LI, Xiao-Rong, KIRUBARAJAN, Thiagalingam, 2001. *Estimation with applications to tracking and navigation* [online]. New York: Wiley PDF e-Book. ISBN 0-471-46521-6, 978-0-471-46521-8. Available via: http://onlinelibrary.wiley.com/book/10.1002/0471221279.
- REIF, Konrad, 2010. *Sensoren im Kraftfahrzeug* [online]. Wiesbaden: Vieweg + Teubner PDF e-Book. ISBN 978-3-8348-1315-2, 978-3-8348-9718-3. Available via: http://dx.doi.org/10.1007/978-3-8348-9718-3.

Testing and Simulation Methods for Vehicle Safety Systems

Module abbreviation:	IAE_TSMS	**Reg.no.:**	7.2.4
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering - Master	Compulsory Subject	1

Responsible for module:	Vaculin, Ondrej
Language of instruction:	English
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h
Subjects of the module:	7.2.4 Testing and Simulation Methods for Vehicle Safety Systems (IAE_TSMS)
Lecture types:	IAE_TSMS: SU/Ü - lecture with integrated exercises
Examinations:	7.2.4 mdlP - oral exam, 15 minutes

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

After successfully completing the module the students

- shall know how to test automotive safety systems and control units while its development process
- shall understand different testing methods and their usage for different types of control units and different criticalities.
- shall know when and how to use simulation as an improvement of the testing process, which types of simulation can be used and their pros and cons.

Content:

- Testing as part of the development process (ISO 26262/ V-Model)
- Testing methods and testing metrics
- Test planning
- Application of simulation based methods
- Components of simulation
- Different model types

Literature:

Compulsory:

None

Recommended:

- GÜHMANN, Clemens, RIESE, Jens, VON RÜDEN, Klaus, 2016. *Simulation and testing for vehicle technology: 7th Conference, Berlin, May 12-13, 2016* [online]. [Cham]: Springer PDF e-Book. ISBN 978-3-319-32345-9. Available via: http://dx.doi.org/10.1007/978-3-319-32345-9.

- KÄPPLER, Wolf Dieter, 2015. *Smart Vehicle Handling - Test und Evaluation in der Fahrzeugtechnik* [online]. PDF e-Book. ISBN 978-3-662-46417-5, 978-3-662-46416-8. Available via: http://dx.doi.org/10.1007/978-3-662-46417-5.
- BAERISCH, Stefan, 2010. *Domain-specific model-driven testing* [online]. PDF e-Book. ISBN 978-3-8348-9624-7, 978-3-8348-0931-5. Available via: http://dx.doi.org/10.1007/978-3-8348-9624-7.