Technische Hochschule Ingolstadt

Program and Course Description
M.Eng. International Automotive Engineering

Faculty of Electrical Engineering and Information Technology

As per: 2023-09-15

Inhalt

1 Introduction

1.1 Overview

In the field of automotive development, strong efforts should be made on national and international level to adequately prepare students for coping with the technical exigencies of future automobiles. Engineers with interdisciplinary knowledge in mechanics, electronics and computer science are particularly wanted. The Master-programme "International Automotive Engineering" (IAE) wants to impart dedicated engineering approaches for the development of automotive mechatronic systems and to give instructions for solving specific problems of developing automotive electronic systems in general as well as for vehicle safety systems specifically.

The programme 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 programme 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 programme means that students learn independently and solely responsible.

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

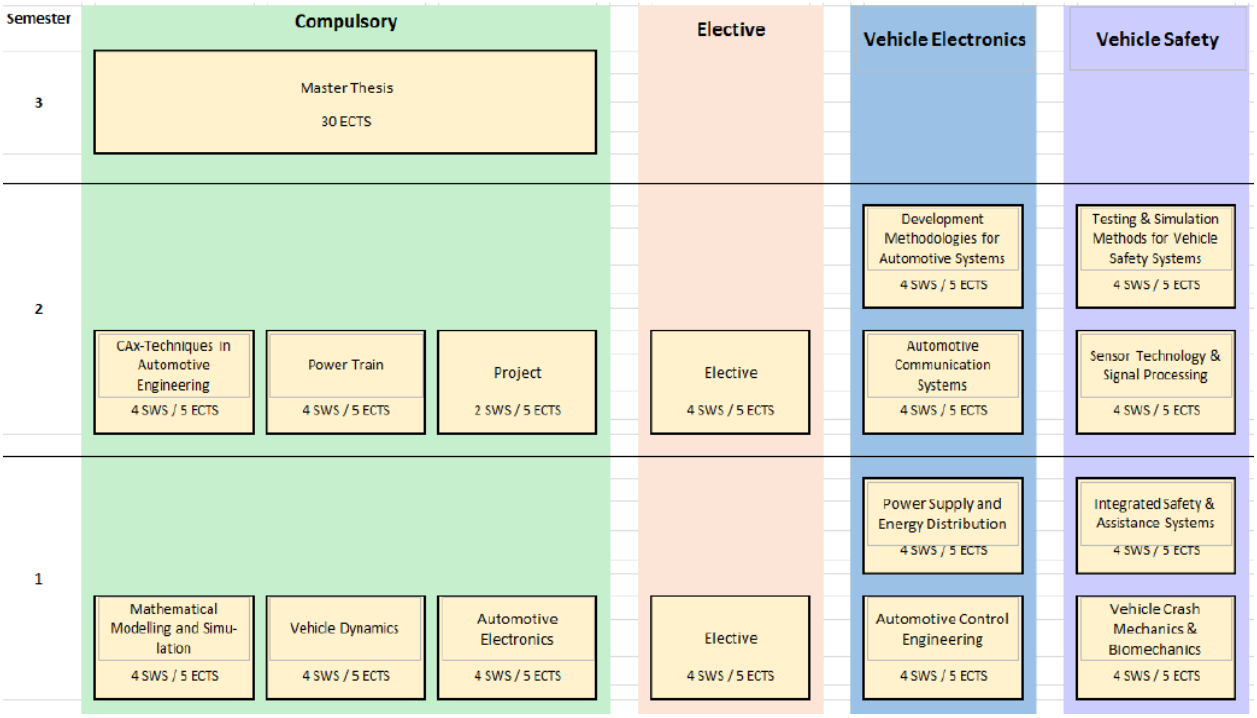

Figure 1: General Programme structure

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 co-operating 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

1.2 Graduation

The Technische Hochschule Ingolstadt awards the academic degree

Master of Engineering (M.Eng.)

1.3 Degree Programme Coordination and Study Counseling

For subject-oriented questions and problems, the course advisor is available:

Prof. Dr. Armin Arnold

Questions related to the organization will be answered by:

Prof. Dr. Armin Arnold

The consultation hours that apply during the semester are announced via Moodle.

2 Basic Structure of the Programme

The Master's programme starts every summer and winter semester. Due to the modular structure of the degree programme it is possible to complete all subjects both at the beginning in the summer and at the beginning in the winter semester. Therefore, not every subject is offered every semester. The following two tables represent the curriculum for a study start in the winter semester or in the summer semester.

2.1 Compulsories

Start in winter

SPO-Nr.	Module	1. Semester			2. Semester			3. Semester	
		SWS	LP	Prfg.	SWS	LP	Prfg.	SWS	LP
1	Mathematical Modelling and Simulation	4	5	WE					
2	Vehicle Dynamics				4	5	WE		
3	Automotive Electronics	4	5	WE					
4	CAx-Techniques in Automotive Engineering				4	5	A		
5	Power Train	4	5	WE					
6	Group Project				2	5	A		
Core area 'Vehicle Electronics									
7.1	Automotive Control Engineering	4	5	WE					
7.2	Power Supply and Energy Distribution	4	5	WE					
7.3	Automotive Communication Systems				4	5	WE		
7.4	Development Methodologies for Automotive Systems				4	5	OE		
Core area 'Vehicle Safety									
8.1	Vehicle Crash Mechanics and Biomechanics	4	5	WE					
8.2	Sensor Technology and Signal Processing	4	5	WE					
8.3	Integrated Safety and Assistance Systems				4	5	WE		
8.4	Testing and Simulation Methods for Vehicle Safety Systems				4	5	OE		
9	Elective	4	5	LN	4	5	LN		
10	Master Thesis							0	30
11	Seminar for Master's thesis							1	0
	Summe	**24**	**30**		**22**	**30**		**1**	**30**

WE written exam
OE oral exam
LN subject-defined exam
A practical assignment

Start in summer

SPO-Nr.	Module	1. Semester			2. Semester			3. Semester	
		SWS	LP	Prfg.	SWS	LP	Prfg.	SWS	LP
1	Mathematical Modelling and Simulation	4	5	WE					
2	Vehicle Dynamics	4	5	WE					
3	Automotive Electronics				4	5	WE		
4	CAx-Techniques in Automotive Engineering	4	5	A					
5	Power Train				4	5	WE		
6	Group Project				2	5	A		
Core area 'Vehicle Electronics									
7.1	Automotive Control Engineering				4	5	WE		
7.2	Power Supply and Energy Distribution				4	5	WE		
7.3	Automotive Communication Systems	4	5	WE					
7.4	Development Methodologies for Automotive Systems	4	5	OE					
Core area 'Vehicle Safety									
8.1	Vehicle Crash Mechanics and Biomechanics				4	5	WE		
8.2	Sensor Technology and Signal Processing				4	5	WE		
8.3	Integrated Safety and Assistance Systems	4	5	WE					
8.4	Testing and Simulation Methods for Vehicle Safety Systems	4	5	OE					
9	Elective	4	5	LN	4	5	LN		
10	Master Thesis							0	30
11	Seminar for Master's thesis							1	0
	Summe	**24**	**30**		**22**	**30**		**1**	**30**

WE written exam
OE oral exam
LN subject-defined exam
A practical assignment

2.2 Electives

Required elective modules are modules offered to students of the degree programme. Each student must complete a total of two elective modules according to the study and examination regulations. The selected modules are treated like compulsory modules. A claim that all envisaged elective modules are actually offered does not exist. Likewise, there is no claim that the associated teaching events are carried out if the number of participants is insufficient. Which modules are offered in the respective semester can be found in the curriculum.

Basically, compulsories of a core area are offered as electives to students having selected the other core area.

Selecting an elective module is as follows:

There is no dedicated selection process for elective modules. Instead, students can attend the courses offered by each elective module.

Then, as part of the examination registration, students specify which elective module they want to take.

2.3 Group Projects

In group projects, a semester-accompanying project task is done by a team of about 10-12 students.

Selecting a group projects is as follows:

In the week before the beginning of the semester, students are asked online to choose the project they are interested in. Due to the limited number of participants per project, it cannot be guaranteed that each student will get a place in his preferred project. Students are encouraged to independently organize project changes.

Before the selection of the projects take place students will be informed about the topics and tasks of the projects offered in the semester.

As part of the examination registration, students have to register which project they should complete with which lecturer.

There is no claim that all planned projects will be actually offered.

3 Description of Modules

3.1 Compulsory Modules

Mathematical Modeling and Simulation			
Module abbreviation:	IAE_MMS	**Reg.no.:**	1
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1

Responsible for module:	Ebert, Bernd Martin		
Lecturer:	Ebert, Bernd Martin		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Mathematical Modeling and Simulation (IAE_MMS)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_MMS)

Additional Explanation:

None

Prerequisites according examination regulation:

None

Recommended prerequisites:

Engineering mathematics
Basics of physics: kinematics, mechanics, electricity, thermodynamics
Relationships between describing variables (force, torque, current, ...) of the mechanical and electrical energy domain
Basics of programming
Basics of control engineering

Objectives:

After successfully completing the module, students shall be able to:

- understand the process of system modelling
- formulate mathematical models of physical systems by means of input/output equations
- model systems of different energy domains in state space representation according to unified approaches
- implement the mathematical model using software tools (e.g. Matlab/Simulink)

- analyze, validate and interpret the simulation results
- assess and design a controller for a given plant

Content:

The following topics are covered:

- modelling of mechanical, electrical, thermo-fluidic and interconnected systems
- linearity: scaling, superposition, linearization of nonlinear processes
- Lagrange formalism of second type to derive equations of motion
- Laplace transforms, transfer functions, and frequency response analysis, behaviour (forced/unforced time and frequency domain responses) of linear time-invariant (LTI) ordinary differential equations.
- numerical integration and computer simulation.
- tools: solution of dynamic problems using a digital simulation packages for continuous time/sampled data systems such as MATLAB/Simulink

Literature:

- 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, Donald L. MARGOLIS and Ronald C. ROSENBERG, 2012. *System dynamics: modeling, simulation, and control of mechatronic systems*. 5. edition. Hoboken: Wiley. ISBN 978-0-470-88908-4, 978-1-118-15982-8
- PALM III, William John, 2021. *System dynamics* . 4. edition. New York, NY: McGraw-Hill. ISBN 978-1-260-57076-2

Additional remarks:

None

CAx-Techniques in Automotive Engineering

Module abbreviation:	IAE_CAX	**Reg.no.:**	2
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1

Responsible for module:	Elger, Gordon		
Lecturer:	Elger, Gordon; Pandey, Amit; Zimmer, Alessandro		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	CAx-Techniques in Automotive Engineering (IAE_CAX)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

prA - practical assignment (IAE_CAX)

Additional Explanation:

Practical assignment: CAD integrated FE or CFD Simulation project which is concluded by a report (approx. 20 pages) and an oral interrogation 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 and theory of FEM
  - Differential equation and boundary conditions
  - Introduction in FEM, FDM,FVM,
  - The principle of virtual work
  - CAE process flow
  - Classification of FE solver
- Finite Element formulation for structural analysis and heat vtransfer
  - Stiffness matrix and Heat transfer matrix
  - Linear and nonlinear analysis
  - Steady state and transient simulation
- Thermal analysis: heat transfer and thermal boundary condition
- Computational fluid dynamics
- Electronic Cooling
- Design of Experiments and Methamodels
- Artificial intelligence in CAE

Literature:

- 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
- GOKHALE, Nitin S. and ET AL., 2008. *Practical finite element analysis*. 1. edition. Pune: Finite to infinite. ISBN 978-81-906195-1-6, 978-81-906195-0-9
- 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.

Additional remarks:

None

Power Train

Module abbreviation:	IAE_PT	**Reg.no.:**	3
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1

Responsible for module:	Birkner, Christian		
Lecturer:	Birkner, Christian		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Power Train (IAE_PT)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_PT)

Additional Explanation:

None

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
- are able to set up models and evaluate results from dynamic drivetrain simulations focussing on the impact of operation principles on factors like driving performance and efficiency

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
- modelling and simulation of different drivetrain concepts

Literature:

- 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.

Additional remarks:

No remarks.

Vehicle Dynamics

Module abbreviation:	IAE_VDS	**Reg.no.:**	4
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1

Responsible for module:	Arnold, Armin		
Lecturer:	Arnold, Armin		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Vehicle Dynamics (IAE_VDS)		
Lecture types:	1: SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_VDS)

Additional Explanation:

None

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 to different scenarios

- Properties of rubber
- Brush model of tire
- Vehicle models (Single track model steady state and dynamically, application to cornering, banked road,, sidewind, iphysical and effective sideslip stiffness)
- Influencing driving behaviour by: means of suspension:
  - Suspension:: Roll- und instant center, (elasto)-kinematics
  - Spring stiffnesses
  - position of center of gravity
  - Distribution of driving- and braking torques
- Drive train influences: Behavior of open differentials, limited slip differentials (viscous and lclutch type, 4WD
- ABS algorithm
- traction control and vehicle stability control
- torque vectoring

Literature:

- 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

Additional remarks:

None

Automotive Electronics

Module abbreviation:	IAE_AES	**Reg.no.:**	5
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1

Responsible for module:	Arnold, Armin		
Lecturer:	Arnold, Armin		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Automotive Electronics (IAE_AES)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_AES)

Additional Explanation:

None

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 automotive electronics architectures
- knowledge of the architecture of automotive control units and applied integrated circuits
- knowledge of automotive sensor technologies
- kowledge of automotive actuator technologies
- comprehension of the functional dependencies
- ability to apply the knowledge to specify and design control units

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

- introduction to automotive electric standards
- basics of automotive sensors and actuators
- basics of automotive software engineering

Literature:

- 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.

Additional remarks:

None

Group Project

Module abbreviation:	IAE_PRJ	**Reg.no.:**	6
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	2

Responsible for module:	Arnold, Armin		
Lecturer:	Chandra Sekaran, Karthikeyan; De Borba, Thiago; Festag, Andreas; Kotak, Yash; Pfaller, Tobias; Riegl, Peter; Rufino, Carlos; Zimmer, Alessandro		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 2 SWS		
Workload:	Contact hours: 24 h Self-study: 101 h Total: 125 h		
Subjects of the module:	Group Project (IAE_PRJ)		
Lecture types:	Prj - Projekt		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

LN - project work (IAE_PRJ)

Additional Explanation:

None

Prerequisites according examination regulation:

None

Recommended prerequisites:

Knowledge mediated in IAE-lectures of first semester

Objectives:

The project goals are

- acquirement of interdisciplinary interrelations
- improvement of methods and social competence.
- ability to develope alternative solutions apart from literature and/or lectures, which solve a given problem
- experiences in the organization of team processes
- acquirement of techniques of moderation and presentation.

Content:

Working on a semester-related project task in a team.

In many cases, the projects are carried out in cooperation with external companies or the university's research center. Alternatively, lecturers also specifically present project topics that are to be processed as part of their teaching or research activities.

Project management and organization are carried out by students. The lecturer acts only as a coach and / or client. The project management method can be classical methods or agile methods such as Scrum or Kanban. The decision about which method to use is up to the project team.

At the beginning of the project, the lecturer clearly communicates his expectations regarding the dates, form and proof of the individual achievements to be provided by all students. The project team agrees with the lecturer / lecturer on the forms of communication and documentation to be adhered to by all project participants (students, lecturer, client) during the project period.

To clarify are:

- frequency and duration of planning sessions
- type and conduct of meetings (shared or virtual / electronic)
- regular meetings (possibly daily in the form of Scrum-Meatings etc,)
- type and scope of deliverables
- type and extent of individual amounts by students
- criteria for assessment / grading by the lecturer

Literature:

Will be specified at the beginning

Additional remarks:

Annotation:

A division of the study group by the election of a project will take place in the second half of September. Before the election, students will be given descriptions of the themes of the projects.

3.2 Compulsories of the Core Area "Vehicle Electronics"

Automotive Control Engineering			
Module abbreviation:	IAE_ACE	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	General Elective Subject	1
Responsible for module:	Gregor, Rudolf		
Lecturer:	Gregor, Rudolf		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Automotive Control Engineering (IAE_ACE)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		
Examinations:			
schrP90 - written exam, 90 minutes (IAE_ACE) Additional Explanation: None			
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 (pole placement, modal control, optimal control) • 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 (SISO and MIMO) • Analysis of system properties (dynamics, stability, (output) controllability, observability) in state space			

- Calculation of the state transition matrix to solve the state equation
- Design of state feedback control (pole placement, modal control, optimal control) to improve system dynamics
- Design og prefilters and integral action for static accuracy
- 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:

- GREGOR, Rudolf, KRÄMER, Wolfgang, 2023. *Slides, exercises, supplementary material.* [online]. PDF e-Book.
- 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*. 1. edition. Oxford [u.a.]: Butterworth-Heinemann. ISBN 0-7506-5100-8
- FRANKLIN, Gene F., J. David POWELL and Abbas EMAMI-NAEINI, 2020. *Feedback control of dynamic systems*. E. edition. New York: Pearson. ISBN 978-1-292-27454-6, 1-292-27452-2
- DORF, Richard C. and Robert H. BISHOP, 2022. *Modern control systems*. F. edition. Harlow, United Kingdom: Pearson. ISBN 978-1-292-42235-0

Additional remarks:

None

Power Supply and Energy Distribution

Module abbreviation:	IAE_PSED	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1

Responsible for module:	Pforr, Johannes		
Lecturer:	Pforr, Johannes		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Power Supply and Energy Distribution (IAE_PSED)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_PSED)

Additional Explanation:

None

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:

Introduction, background and design of vehicular electrical energy distribution networks and power electronic systems and devices:

- 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:

- VELTMAN, André, PULLE, Duco W. J., DE DONCKER, Rik W., 2016. *Fundamentals of Electrical Drives* [online]. Cham: Springer International Publishing PDF e-Book. ISBN 978-3-319-29409-4, 978-3-319-29408-7. Available via: https://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

Additional remarks:

No remarks.

Automotive Communication Systems

Module abbreviation:	IAE_ACS	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Specialised Elective Subject	1

Responsible for module:	Frey, Andreas (Prof.)		
Lecturer:	Frey, Andreas (Prof.)		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Automotive Communication Systems (IAE_ACS)		
Lecture types:	1: SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_ACS)

Additional Explanation:

None

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
- understand the fundamentals of wired bus systems
- know the details of the main bus systems are able to apply those details in specific communication scenarios
- 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
  - 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
  - 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:

- 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

Additional remarks:

None

Development Methodologies for Automotive Systems

Module abbreviation:	IAE_DMAS	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	General Elective Subject	1

Responsible for module:	Margull, Ulrich		
Lecturer:	Margull, Ulrich		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Development Methodologies for Automotive Systems (IAE_DMAS)		
Lecture types:	1: SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

oral exam - 15 - 30 min. (IAE_DMAS)

Additional Explanation:

None

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. Students will be able to develop and design software for embedded, automotive, real-time systems using AUTOSAR. They will have a basic understanding of the overall software development process for automotive systems.

Content:

- Introduction: cyber-physical systems, automotive E/E systems
- Automotive microcontrollers: architecture, memory
- Fundamentals of microcontroller programming: structure of automotive software, memory mapping, fixed point and floating point arithmetics
- 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), supporting processes (e.g. versioning with git, requirments tracing)

• AUTOSAR development process for Classic (Virtual Function Bus, Application Components, RTE, BSW, AUTOSAR OS) and Adaptive AUTOSAR
Literature:
• MARWEDEL, Peter, 2021. *Embedded system design: embedded systems foundations of cyber-physical systems, and the Internet of Things* [online]. Cham, Switzerland: Springer PDF e-Book. ISBN 978-3-030-60909-2, 978-3-030-60910-8. Available via: https://doi.org/10.1007/978-3-030-60910-8. • LEE, Edward A. and Sanjit Arunkumar SESHIA, 2017. *Introduction to embedded systems: a cyber-physical systems approach*. S. edition. Cambridge, Massachuetts: MIT Press. ISBN 978-0-262-53381-2 • Without author, 2016. *AUTOSAR* [online]. , 10.6.2016 [Accessed on: 10.6.2016]. Available via: autosar.org • SCHÄUFFELE, Jörg and Thomas ZURAWKA, 2016. *Automotive software engineering: principles, processes, methods, and tools*. S. edition. Warrendale, Pennsylvania, USA: SAE International. ISBN 978-0-7680-7992-0
Additional remarks:
None

3.3 Compulsories of the Core Area "Vehicle Safety"

Vehicle Crash Mechanics and Biomechanics			
Module abbreviation:	IAE_VCM	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1
Responsible for module:	Brandmeier, Thomas		
Lecturer:	Brandmeier, Thomas		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Vehicle Crash Mechanics and Biomechanics (IAE_VCM)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_VCM)

Additional Explanation:

None

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:
Will be specified at the beginning
Additional remarks:
None

Integrated Safety and Assistance Systems

Module abbreviation:	IAE_ISAS	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	General Elective Subject	1

Responsible for module:	Botsch, Michael		
Lecturer:	Botsch, Michael; Dirndorfer, Tobias		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Integrated Safety and Assistance Systems (IAE_ISAS)		
Lecture types:	1: SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty, but it is offered as an elective moudle in other Master degree programmes of the faculty.. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 – schriftliche Prüfung 90 Minuten (IAE_ISAS)

Additional Explanation:

None

Prerequisites according examination regulation:

Mathematics for Engineers

Recommended prerequisites:

None

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:

- 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, 2016. *Chassis Handbook: Fundamentals, Driving Dynamics, Components, Mechatronics, Perspectives* [online]. Wiesbaden: Vieweg+Teubner PDF e-Book. ISBN ISBN-10: 3663205193; ISBN-13: 978-3663205197.
- WINNER, Hermann, HAKULI, Stephan, LOTZ, Felix, SINGER, Christina, 2019-. *Handbook of Driver Assistance Systems: Basic Information, Components and Systems for Active Safety and Comfort* [online]. Cham: Springer International Publishing PDF e-Book. ISBN 978-3-319-09840-1. Available via: https://doi.org/10.1007/978-3-319-09840-1.
- BOTSCH, Michael, UTSCHICK, Wolfgang, 2020. *Fahrzeugsicherheit und automatisiertes Fahren: Methoden der Signalverarbeitung und des maschinellen Lernens* [online]. PDF e-Book. ISBN 978-3-446-46804-7.

Additional remarks:

No remarks.

Sensor Technology and Signal Processing

Module abbreviation:	IAE_ST&SP	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	General Elective Subject	1

Responsible for module:	Botsch, Michael		
Lecturer:	Botsch, Michael		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Sensor Technology and Signal Processing (IAE_ST&SP)		
Lecture types:	SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty, but it is offered as an elective moudle in other Master degree programmes of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

schrP90 - written exam, 90 minutes (IAE_ST&SP)

Additional Explanation:

None

Prerequisites according examination regulation:

Mathematics for Engineers

Recommended prerequisites:

None

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:

- 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, 2016. *Sensoren im Kraftfahrzeug* [online]. Wiesbaden: Springer Vieweg PDF e-Book. ISBN 978-3-658-11211-0, 978-3-658-11210-3. Available via: https://doi.org/10.1007/978-3-658-11211-0.
- BOTSCH, Michael and Wolfgang UTSCHICK, 2020. *Fahrzeugsicherheit und automatisiertes Fahren: Methoden der Signalverarbeitung und des maschinellen Lernens* . ISBN 978-3-446-45326-5

Additional remarks:

None

Testing and Simulation Methods for Vehicle Safety Systems

Module abbreviation:	IAE_TSMS	**Reg.no.:**	7
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	1

Responsible for module:	Vaculin, Ondrej		
Lecturer:	Vaculin, Ondrej		
Language of instruction:	English	**Language of exam:**	English
Credit points / SWS:	5 ECTS / 4 SWS		
Workload:	Contact hours: 47 h Self-study: 78 h Total: 125 h		
Subjects of the module:	Testing and Simulation Methods for Vehicle Safety Systems (IAE_TSMS)		
Lecture types:	1: SU/Ü - seminaristischer Unterricht/Übung		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

mdlP - oral exam, 15 minutes (IAE_TSMS)

Additional Explanation:

None

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:

- Vehicle Approval Process, Consumer Testing
- Testing as part of the development process (ISO 26262/ V-Model)
- Testing methods and testing metrics%0A
  - Electrical Safety
  - Passive Safety
  - Active Safety
  - Automated Driving

• Application of simulation based methods • Components of simulation • Different model types
Literature:
Will be specified at the beginning
Additional remarks:
None

3.4 Additional modules for all core-areas

Master's Thesis			
Module abbreviation:	IAE_THESIS	**Reg.no.:**	10
Curriculum:	**Programme**	**Module type**	**Semester**
	International Automotive Engineering (SPO WS 15/16)	Compulsory Subject	3

Responsible for module:	Arnold, Armin		
Lecturer:	Alle Professorinnen/Professoren,		
Language of instruction:	German/English	**Language of exam:**	German/English
Credit points / SWS:	30 ECTS / 1 SWS		
Workload:	Contact hours: 12 h Self-study: 738 h Total: 750 h		
Subjects of the module:	Master´s Thesis (IAE_THESIS)		
Lecture types:	unspecified (IAE_THESIS)		
Availability of the module:	This module is not a compulsory module in any other degree programme of the faculty. When changing to a degree programme of another faculty, the possibilities for credit transfer must be discussed with the responsible persons.		

Examinations:

Master-Thesis (IAE_THESIS)

Additional Explanation:

In general, students look for a topic for their thesis on their own. Topics are either offered internally by university lecturers in notices (also online) or result from the cooperation of the student with a company. In the case of an externally provided topic, the student must convince a university lecturer of his or her topic so that the lecturer assumes the role of the first examiner. For this purpose, it is advisable to outline the topic and the planned approach in a short paper. This exposé serves to convince the lecturer desired as the first examiner.

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:

After successfully completing the master's thesis, students are able to

- to work on a complex engineering problem from the subject area of the study program within a limited period of time and a possibly given budget according to scientific methods in a qualified and independent manner
- systematically and creatively develop solutions for similar problems
- determine and evaluate the limits of the solution presented

- to prepare the problem definition, its classification in an overall context as well as a presentation and discussion of the problem solution and the results in compliance with the rules for scientific texts (stringency, transparency, etc.) and formal criteria
- follow good scientific practice and apply scientific working methods

Content:

The master's thesis is a graduation thesis in engineering specific to the course of study. The topic of the master's thesis is set, supervised and accompanied in terms of content by a professor from the participating universities. The topic can be worked on in practice, e.g. in a company, or in research at the THI.

- scientific analysis of a complex problem specific to the course of study against the background of the state of the art in science and technology.
- literature research, especially considering current international publications in scientific journals
- development of a creative solution concept appropriate to the context of the problem, taking into account current scientific, technical and operational aspects
- comprehensive evaluation of alternative solution concepts and selection of the best solution concept (technical, economic evaluation)
- implementation of the selected solution concept of the complex problem specific to the course of study
- critical and comprehensive analysis of the obtained results using appropriate engineering methods
- project management (especially time and, if necessary, budget management)
- comprehensible and formally correct presentation and documentation of the solution and results
- good scientific practice and scientific working methods

Literature:

Will be specified at the beginning

Additional remarks:

Important Notes: Keep your supervisors and primary examiners regularly informed of your progress. In particular, clarify their expectations regarding the content of the thesis. A whole semester is estimated for working on the Master's thesis (30 credit points), whereas only 12 credit points are estimated for working on the Bachelor's thesis. This shows that the requirements for the scope and content of a Master's thesis are much higher than for a Bachelor's thesis. In particular, the scientific character should be emphasized more strongly in a Master's thesis:

- statements should, wherever possible, be placed in the context of relevant technical literature.
- in addition to conventional technical literature, sources from current research (e.g., dissertations and conference papers) should be substantially included.
- the graduate's working methods should be purposeful, methodical, and systematic, and should be explicitly documented in the thesis
- quantitative statements, such as measurements, should be investigated and documented using the tools of mathematical statistics.