Course Handbook Automotive Engineering Master

created at 08.01.2024,13:41

Head of Studies	Prof. Dr.-Ing. Rüdiger Tiemann
Deputy Head of Studies	Prof. Dr. Hans-Werner Groh
Chairman of Examination	Prof. Dr.-Ing. Jochen Gessat
Deputy Chairman of Examination	Prof. Dr. Jörg Hoffmann

Qualifikation Goals of Study Programme

Automotive Engineering Master - mandatory courses (overview)

Module name (EN)	Code	SAP-P	Semester	Hours per semester week / Teaching method	ECTS	Module coordinator
CAE and Modern Calculation Methods	FTM-CAE	P242-0105	1	3V+1U+1P	6	Prof. Dr. Frank Ulrich Rückert
Embedded Programming	FTM-HPRG	P242-0108, P242-0109, P242-0121	1	3V+1U+1P	6	Prof. Dr. Hans-Werner Groh
New Development Trends in Vehicle Engineering	FTM-ENTW	P242-0111, P242-0112, P242-0122	2	4SU+1U	6	Prof. Dr.-Ing. Thomas Heinze
Simulation Theory and Application	FTM-MATH	P242-0104	2	5V	6	Prof. Dr. Marco Günther
The Programming and Application of Electrical Vehicle Systems	FTM-PAEF	P242-0113, P242-0114, P242-0123	2	3V+1U+1P	6	Prof. Dr.-Ing. Thomas Heinze
Virtual Vehicle Development	FTM-VFZG	P242-0117, P242-0118	1	3V+1U+1P	6	Prof. Dr. Hans-Werner Groh

(6 modules)

Automotive Engineering Master - optional courses (overview)

Module name (EN)	Code	SAP-P	Semester	Hours per semester week / Teaching method	ECTS	Module coordinator
Bionics in Automotive Engineering	FTM-BIO	P242-0101	1	2V	3	Prof. Dr.-Ing. Hans-Joachim Weber
Entrepreneurship in Engineering	FTM-ENT	P242-0102	1	3V	3	Prof. Dr. Jörg Hoffmann
Experiment Design and Quality Control	FTM-VUQ		-	2V	3	Prof. Dr. Gerald Kroisandt
Failure Analysis in Operational and Manufacturing Environments	FTM-SABF	P241-0363	-	1V	2	Prof. Dr. Moritz Habschied
Fibre-Reinforced Composites: Calculation and Praxis	FTM-FBP	P241-0345	1	1V+3PA	5	Prof. Dr. Moritz Habschied
IT and TC Law	FTM-ITR		1	2V	3	RA Cordula Hildebrandt
Systems Engineering and Modern Simulation Methodologies	FTM-SEMS	P242-0125	2	-	3	Prof. Dr.-Ing. Rüdiger Tiemann
Traffic Control and Traffic Management	FTM-KVUV	P222-0097	2	4V	6	Prof. Dr. Horst Wieker

(8 modules)

Automotive Engineering Master - mandatory courses

CAE and Modern Calculation Methods

Module name (EN): CAE and Modern Calculation Methods
Degree programme: Automotive Engineering, Master, ASPO 01.04.2023
Module code: FTM-CAE
Hours per semester week / Teaching method: 3V+1U+1P (5 hours per week)
ECTS credits: 6
Semester: 1
Mandatory course: yes
Language of instruction: German
Assessment: [*still undocumented*]
Applicability / Curricular relevance: FTM-CAE (P242-0105) Automotive Engineering, Master, ASPO 01.04.2021 , semester 1, mandatory course FTM-CAE (P242-0105) Automotive Engineering, Master, ASPO 01.04.2023 , semester 1, mandatory course
Workload: 75 class hours (= 56.25 clock hours) over a 15-week period. The total student study time is 180 hours (equivalent to 6 ECTS credits). There are therefore 123.75 hours available for class preparation and follow-up work and exam preparation.
Recommended prerequisites (modules): None.
Recommended as prerequisite for:
Module coordinator: Prof. Dr. Frank Ulrich Rückert
Lecturer: Prof. Dr. Frank Ulrich Rückert [*updated 20.12.2021*]
Learning outcomes: After successfully completing this module, students will have acquired theoretical and practical knowledge about modern simulation methods for the advance planning of the system behavior, function, structure, life cycle and sustainability of vehicle systems and their components.

They will be able to understand and master the use and handling of powerful 1D/3D CAE systems, as well as 3D printing, in particular the properties of process media and materials. In addition, they will be able to perform couplings of strength, flow, and thermal simulations.

Based on finite element methods and finite volume methods, in combination with statistical design of experiments (DOE), students will be able to evaluate development parameters and develop vehicle systems and their components to specification.

[*updated 01.07.2021*]

Module content:
- Specific algorithms and procedures when working with 1D and 3D CAE systems
- Methods for the design and additive manufacturing of complex individual parts and assemblies, as well as for the creation of digital twins based on individual part and assembly drawings
- CAE tools: kinematic simulation, installation simulation, parametric design, manufacturing simulation, temperature simulation, vibration behavior using digital twins
- Overview of modern calculation methods of finite elements and the finite volume method
- Introduction to the setup of a more system-technical design tool (Simcenter Amesim)
- Introduction to a commercial CFD/FEM code (ANSYS Workbench)
- Practical 3D flow simulation and structural analysis with ANSYS Workbench

[*updated 01.07.2021*]

Teaching methods/Media:
Team building through learning team coaching (LTC) methods; seminar-style, interactive course based on blended learning. Installation of the CAE tools at home and use in the PC-pool to create the digital twin. Work in the hands-on learning workshops. Worksheets and video tutorials. Online meetings using MS Teams.

[*updated 01.07.2021*]

Recommended or required reading:
- Huei-Huang Lee: Finite Element Simulations with ANSYS Workbench 19; ISBN-13 978-1-63057-211-2
- Willi Bohl, Walter Wagner: Technische Strömungslehre; Vogel Verlag; ISBN 3-8023-0576-0
- Rolf Steinbuch: Finite Elemente Ein Einstieg; ISBN 3-540-63128-3
- Yunus A. Cengel, Afshin J. Ghajar: Heat and Mass Transfer Fundamentals & Applications; ISBN-13: 978-93-392-2319-9
- Berthold Noll; Numerische Strömungsmechanik Grundlagen; Springer Verlag; ISBN 3-540-56712-7
- Christof Gebhardt: Praxisbuch FEM mit ANSYS Workbench Einführung in die lineare und nichtlineare Mechanik; ISBN 978-3-446-42517-0
- Florian Kramer: Integrale Sicherheit von Kraftfahrzeugen; Springer Verlag; ISBN 978-3-8348-2608-4
- Qasim Shah: LS-DYNA für Einsteiger; AV Akademikverlag; ISBN 978-620-2-22602-8

[*updated 01.07.2021*]

Embedded Programming

Module name (EN): Embedded Programming

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-HPRG

Hours per semester week / Teaching method:
3V+1U+1P (5 hours per week)

ECTS credits:
6

Semester: 1

Mandatory course: yes

Language of instruction:
German

Assessment:
Written exam (programming exercises) 180 min.

[*updated 04.09.2023*]

Applicability / Curricular relevance:

FTM-HPRG (P242-0108, P242-0109, P242-0121) Automotive Engineering, Master, ASPO 01.04.2021 , semester 1, mandatory course
FTM-HPRG (P242-0108, P242-0109, P242-0121) Automotive Engineering, Master, ASPO 01.04.2023 , semester 1, mandatory course

Workload:
75 class hours (= 56.25 clock hours) over a 15-week period.
The total student study time is 180 hours (equivalent to 6 ECTS credits).
There are therefore 123.75 hours available for class preparation and follow-up work and exam preparation.

Recommended prerequisites (modules):
None.

Recommended as prerequisite for:

Module coordinator:
Prof. Dr. Hans-Werner Groh

Lecturer: Prof. Dr. Hans-Werner Groh

[*updated 20.12.2021*]

Learning outcomes:
After successfully completing this module, students will understand how microcontrollers operate and will thus, be able to integrate them into control and regulation processes.
They will be able to independently learn specific functions of unknown microcontrollers by working with the corresponding data sheets.

- They will have mastered the C programming language to create algorithms and thus, be able to solve existing technical problems when using microcontrollers.

- They will be able to abstract practical problems to the point where they can replicate real-world problems on emulators.

- They will be able to program microcontrollers quickly and efficiently using graphical interfaces.

[*updated 04.09.2023*]

Module content:
- The way microcontrollers work, especially I/O, registers, and interfaces. Using processor data sheets to initialize controller functions.

- Advanced knowledge of the C programming language, especially control structures, functions, pointers and declarations.
- The way a compiler works and how compiler results are represented in Assembler code.
- Special hardware-specific programming methods and requirements such as fixed-point arithmetic, code efficiency, offloading to hardware functions, interrupt control and fail safety.

- Methods for meeting real-time requirements such as interrupt handling of fast external events, programming time-deterministic routines such as controllers, filters.

- Ways to integrate microcontroller hardware into a technical process: sensor signal conditioning, actuator control (power electronics), as well as recording and showing process variables.

Based on this, the use of C-programmed algorithms for processing various I/O signals.
- Ways to automatically generate code from Matlab/Simulink for Dspace and Arduino hardware to create control systems.

- Purpose and systematics of hardware-in-the-loop simulations. Creating emulators for use in a HiL environment.

- Applying what was learned in a larger project at the end of the semester in preparation for a practical exam.

[*updated 04.09.2023*]

Teaching methods/Media:
- Lecture with corresponding programming exercises
- Term paper as final project

[*updated 25.05.2021*]

Recommended or required reading:
- Data sheets for the processors and evaluation boards used (Arduino)
- User manuals of the HiL systems used (dSPACE)

[*updated 25.05.2021*]

New Development Trends in Vehicle Engineering

Module name (EN): New Development Trends in Vehicle Engineering
Degree programme: Automotive Engineering, Master, ASPO 01.04.2023
Module code: FTM-ENTW

Hours per semester week / Teaching method: 4SU+1U (5 hours per week)
ECTS credits: 6
Semester: 2
Mandatory course: yes
Language of instruction: German
Assessment: Written exam (90 min.) [*updated 09.11.2022*]
Applicability / Curricular relevance: FTM-ENTW (P242-0111, P242-0112, P242-0122) Automotive Engineering, Master, ASPO 01.04.2021 , semester 2, mandatory course FTM-ENTW (P242-0111, P242-0112, P242-0122) Automotive Engineering, Master, ASPO 01.04.2023 , semester 2, mandatory course
Workload: 75 class hours (= 56.25 clock hours) over a 15-week period. The total student study time is 180 hours (equivalent to 6 ECTS credits). There are therefore 123.75 hours available for class preparation and follow-up work and exam preparation.
Recommended prerequisites (modules): None.
Recommended as prerequisite for:
Module coordinator: Prof. Dr.-Ing. Thomas Heinze
Lecturer: Prof. Dr. Hans-Werner Groh Prof. Dr.-Ing. Thomas Heinze Prof. Dr. Jörg Hoffmann Prof. Dr.-Ing. Rüdiger Tiemann M.Eng. Michael Fries [*updated 03.11.2023*]
Learning outcomes: H.-W. Groh: Wireless applications in and about the vehicle After sucessfully completing this module, students will be able to evaluate the specifics of high-frequency signal generation in a transmitter, the propagation of such signal, and its processing in a receiver. In particular, they will be able to apply this transmission technology to the automotive field, recognize the

special challenges associated with this environment and, based on this, derive solution approaches for implementation.

TH. Heinze / M. Fries:
Students will be familiar with the latest developments and trends in engine development based on current cases. They will be able to edit technical articles and understand important features of new innovative technical solutions and processes and associate them with the ongoing state of the art. Students will be able to keep up with the development departments in the automotive industry by being familiar with new technical terms, solution approaches and the tool chains used. By studying and discussing professional articles in the course, students learn to work with them.

R. Tiemann: Mechatronische Systeme zur geregelten Längs-/Quer- und Vertikaldynamik im Fahrwerk
Students will be able to explain, analyze and evaluate new vehicle systems for vehicle dynamics control, categorized into longitudinal/transverse dynamics and vertical dynamics. They will be able to evaluate the interaction of wheel-slip control with regard to driving characteristics. In this context, they will be able to analyze the effects and impact of new OEM systems and explain their advantages and disadvantages. More specifically, they will be able to illustrate the distinction between the control of e-differentials, ESP single wheel, all-wheel steering. Furthermore, they will be able to can evaluate new suspension/damping systems by comparing and describing the conflict between driving safety and comfort (sky-hook control). Finally, they will be able to explain and evaluate the individual systems in a fully networked vehicle in terms of the interaction between chassis, vehicle and driver.

J. Hoffmann: Integral vehicle safety
Students will be familiar with the currently relevant development status cases, as well as emerging technological trends in integral vehicle safety. They will be able to review, interpret and edit relevant technical articles on active and passive vehicle safety, describe the important features of new technical solutions and classify them according to the state of the art. Furthermore, they will be able to analyze and evaluate the operating principles of new technologies. They will also be familiar with new legal requirements, technical terms, solution approaches and evaluation methods.

[*updated 09.11.2022*]

Module content:
H.-W. Groh: Radio-based applications in and around the vehicle
- Introduction to high-frequency technology
- Signal level of a satellite transmission link
- Noise, noise figure, iterative noisy two-port network
- Types of antennas and their equivalent circuits
- Transmission lines, reflection coefficients, S-parameters
- Frequency conversion (mixer)
- Analog modulation methods (AM, FM, PM) and their spectra
- Digital modulation methods (ASK, FSK, PSK)
- Higher-level modulation methods (QAM, QPSK)
- Mobile radio channel
- OFDM (DAB, DVB, WLAN)
- Electromagnetic compatibility (EMC)
- Vehicle access control systems

TH. Heinze / M. Fries:
Engine technology, engine control systems and exhaust gas purification systems. The specific content is derived mainly from articles currently published in MTZ - Motortechnische Zeitschrift. The following topics will be discussed separately:
- E-Turbos

- Expansion extension (Miller/Atkinson)
- Cylinder deactivation
- Variable compression
- HCCI / SPCCI
- Hydrogen engines

R. Tiemann: Mechatronic systems for controlled longitudinal/transverse and vertical dynamics in the chassis
- Introduction new chassis systems
- Controlled lateral dynamics with ESP, e-differential, torque vectoring, e-transverse stabilizer
- Controlled lateral dynamics with steering (superimposed steering, all-wheel steering)
- Controlled vertical dynamics, with variable damping and suspension (CVD, ABC), (gas/air suspension, e-roll stabilizer, other)
- View of the overall mechatronic system: chassis-vehicle-driver (chain of action from road to driver)

J. Hoffmann:
The content is mainly derived from current articles in automotive journals and conferences, as well as new demands from consumer protection organizations. Topics relating to passive safety, driver assistance systems, functional safety and lightweight design strategies.

[*updated 09.11.2022*]

Teaching methods/Media:
- Work on documents from specialized, technical literature and product descriptions
- Professional discussions based on student contributions
- Articles on technical topics

[*updated 09.11.2022*]

Recommended or required reading:
H.-W. Groh:
- Meinke, H.; Gundlach, F.: Taschenbuch der Hochfrequenztechnik, Springer, 2006
- Zinke, O.; Brunswig, H.: Hochfrequenztechnik I   Hochfrequenzfilter, Leitungen, Antennen, Springer, 2000
- Zinke, O.; Brunswig, H.: Hochfrequenztechnik II   Elektronik und Signalverarbeitung, Springer, 1999

R. Tiemann:
- OEM technology portals
- Technical articles from ATZ
- Reif, K. (Hrsg.); Grundlagen Fahrzeug- und Motorentechnik, Springer Vieweg, ISBN 978-3-658-12636-0 (eBook)
- Heißing, B., Ersoy, M., Gies, St., (Hrsg.), Fahrwerkhandbuch, Springer Vieweg Fachmedien Wiesbaden, 2013, ISBN 978-3-658-01992-1 (eBook)
- Pischinger, St., Seiffert, U., Vieweg Handbuch Kraftfahrzeugtechnik, 8. Auflage, Springer Vieweg, Wiesbaden, 2016, ISBN 978-3-658-09528-4 (eBook)

TH. Heinze / M. Fries:
- MTZ - Motortechnische Zeitschrift (Electronic ISSN 2192-8843, Print ISSN 0024-8525)

J. Hoffmann:
- ATZ - Automobiltechnische Zeitschrift
- ESV - International Technical Conference on the Enhanced Safety of Vehicles

[*updated 09.11.2022*]

Simulation Theory and Application

Module name (EN): Simulation Theory and Application
Degree programme: Automotive Engineering, Master, ASPO 01.04.2023
Module code: FTM-MATH
Hours per semester week / Teaching method: 5V (5 hours per week)
ECTS credits: 6
Semester: 2
Mandatory course: yes
Language of instruction: German
Assessment: Written exam (90 min.) [*updated 09.11.2022*]
Applicability / Curricular relevance: FTM-MATH (P242-0104) Automotive Engineering, Master, ASPO 01.04.2021 , semester 2, mandatory course FTM-MATH (P242-0104) Automotive Engineering, Master, ASPO 01.04.2023 , semester 2, mandatory course
Workload: 75 class hours (= 56.25 clock hours) over a 15-week period. The total student study time is 180 hours (equivalent to 6 ECTS credits). There are therefore 123.75 hours available for class preparation and follow-up work and exam preparation.
Recommended prerequisites (modules): None.
Recommended as prerequisite for:
Module coordinator: Prof. Dr. Marco Günther

Lecturer: Prof. Dr. Marco Günther

[*updated 20.12.2021*]

Learning outcomes:
In the context of engineering problems, students will be familiar with the basics of mathematical modeling and numerical methods. They will be familiar with the basic properties of partial differential equations, simple solution methods and know about the possibilities and limitations of numerical methods using the finite difference method. They will understand the procedure and properties of the finite element method through the use of a simulation tool.

[*updated 09.11.2022*]

Module content:
- Basics of vector analysis
- Basics of partial differential equations
- Second order lineare partial differential equations (PDEs)
  Derivation of classic 2nd order PDEs, solution by separation approach
- Basic concepts of numerics (like stability, convergence, error)
- Finite Differences Method (FDM)
- Applying the FDM to boundary value problems and initial boundary value problems
- Implementation of numerical methods for solving PDEs in an environment such as Octave/Matlab.
- Basics of the Finite Element Method (FEM)
- Comsol Multiphysics as a simulation tool and the numerical calculation of PDEs
- Simple basics and simulations with Simulink

[*updated 09.11.2022*]

Teaching methods/Media:
The event will be conducted according to the LTC method (LTC=Learn Team Coaching).

[*updated 09.11.2022*]

Recommended or required reading:
Angermann A., Beuschel M, Rau M., Wohlfarth U.: MATLAB Simulink Stateflow
Knabner P., Angermann L.: Numerik partieller Differentialgleichungen
Schwarz: Numerische Mathematik

[*updated 09.11.2022*]

The Programming and Application of Electrical Vehicle Systems

Module name (EN): The Programming and Application of Electrical Vehicle Systems

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-PAEF

Hours per semester week / Teaching method:
3V+1U+1P (5 hours per week)

ECTS credits:
6

Semester: 2

Mandatory course: yes

Language of instruction:
German

Assessment:
Oral examination

[*updated 30.10.2023*]

Applicability / Curricular relevance:

FTM-PAEF (P242-0113, P242-0114, P242-0123) Automotive Engineering, Master, ASPO 01.04.2021 , semester 2, mandatory course
FTM-PAEF (P242-0113, P242-0114, P242-0123) Automotive Engineering, Master, ASPO 01.04.2023 , semester 2, mandatory course

Workload:
75 class hours (= 56.25 clock hours) over a 15-week period.
The total student study time is 180 hours (equivalent to 6 ECTS credits).
There are therefore 123.75 hours available for class preparation and follow-up work and exam preparation.

Recommended prerequisites (modules):
None.

Recommended as prerequisite for:

Module coordinator:
Prof. Dr.-Ing. Thomas Heinze

Lecturer: Prof. Dr.-Ing. Thomas Heinze

[*updated 20.12.2021*]

Learning outcomes:
After successfully completing this course, students will be familiar with the structure and design of modern control units and be able to program and apply them.

[*updated 30.10.2023*]

Module content:
- Difference between programming & application
  Programming
  ECU structure
  Object-related programming
  ASCET / ESDL
  V-model , DevOps
  HIL, SIL, MIL, rapid prototyping

- Autosar-OS (real-time operating system)
  State machines
  Application
  Interfaces
- CCP / ETK / (Zukunft 1000Base-T1/1000Base-RH)
  ASAM MCD 2 MC (*.a2l) and *.hex file
  PLACE OF BIRTH
  Working environment, project, experiment
  Work, reference page
  Variables
  Measuring grid
  Application data manager
  Cut-outs

[*updated 30.10.2023*]

Teaching methods/Media:
Lecture with exercises

[*updated 30.10.2023*]

Recommended or required reading:
Automotive Software Engineering; Jörg SchäuffeleThomas Zurawka; ISBN:978-3-8348-9368-0
Fahrzeuginformatik; Fabian Wolf; ISBN: 978-3-658-21224-7

[*updated 30.10.2023*]

Virtual Vehicle Development

Module name (EN): Virtual Vehicle Development

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-VFZG

Hours per semester week / Teaching method:
3V+1U+1P (5 hours per week)

ECTS credits:
6

Semester: 1

Mandatory course: yes

Language of instruction:
German

Assessment:
Written exam (180 minutes)

[*updated 04.09.2023*]

Applicability / Curricular relevance:

FTM-VFZG (P242-0117, P242-0118) Automotive Engineering, Master, ASPO 01.04.2021 , semester 1, mandatory course
FTM-VFZG (P242-0117, P242-0118) Automotive Engineering, Master, ASPO 01.04.2023 , semester 1, mandatory course

Workload:
75 class hours (= 56.25 clock hours) over a 15-week period.
The total student study time is 180 hours (equivalent to 6 ECTS credits).
There are therefore 123.75 hours available for class preparation and follow-up work and exam preparation.

Recommended prerequisites (modules):
None.

Recommended as prerequisite for:

Module coordinator:
Prof. Dr. Hans-Werner Groh

Lecturer: Prof. Dr. Hans-Werner Groh

[*updated 20.12.2021*]

Learning outcomes:
H.-W. Groh: Image processing (1 V + 1 U/P)
After successfully completing this part of the module, students will be able to read out images from files, from video files, or from a camera, display them on the screen, and post-process them (e.g., convert them) as required.

M. Fries / TH. Heinze: GT-Power (1 V + 0.5 U/P)
After successfully completing this part of the module, students will be able to simulate the catalysts of internal combustion engines in terms of their flow behavior and pollutant conversion.

R. Tiemann: Introduction to multi-body simulation (MBS) based on the example of the automobile. (1 V + 0.5 U/P)
Today´s automotive development is characterized by the use of many calculation and simulation software tools. After sucessfully completing this part of the module, students will be familiar with the existing systems and how they work.
- Simulation methods
- Multibody simulation (MBS); contents, performance, limitations, providers.
- Designing vehicle models, use of control systems for longitudinal and lateral dynamics, e.g. ABS, TCS, ESC
- Virtual test drives

[*updated 04.09.2023*]

Module content:
H.-W. Groh: Image processing (1 V + 1 U/P)
- Introduction to the C++ programming language
- Introduction to the programming environment Qt + OpenCV

- Examples and your own programs for reading, analyzing and editing image files

M. Fries / TH. Heinze: GT-Power (1 V + 0.5 U/P)
- Creating the flow components and the catalyst block (monolith)
- Defining catalytic properties: surface (washcoat), loading (precious metals)
- Applying surface reactions
- Calibrating the model by means of experimental data

R. Tiemann: Introduction to multi-body simulation (MBS) based on the example of the automobile. (1 V + 0.5 U/P)
- Methods for simulating mechanical systems
- Setting up simulations with rigid multibodies (MBS)
- Identifying the performance and limitations of MBS
- SiL, MiL, HiL, ViL terms
- Introduction to the CarMaker software from IPG Automotive
- Structure of (partial) vehicle models
- Virtual test maneuver trials

[*updated 04.09.2023*]

Teaching methods/Media:
H.-W. Groh: Image processing (1 V + 1 U/P)
Lecture with practical exercises on the PC

M. Fries / TH. Heinze: GT-Power (1 V + 0.5 U/P)
Lecture with practical exercises on the PC

R. Tiemann: Introduction to multi-body simulation (MBS) based on the example of the automobile. (1 V + 0.5 U/P)
Lecture mit projector (video), practical exercises using the CarMaker (IPG) software, as well as demonstrations by IPG Automotive

[*updated 04.09.2023*]

Recommended or required reading:
H.-W. Groh: Image processing
- Ulrich Breymann: Der C++-Programmierer, 4., überarbeitete und erweiterte Auflage, Carl Hanser Verlag München 2015, Print-ISBN: 978-3-446-44346-4, E-Book-ISBN: 978-3-446-44404-1

M. Fries / TH. Heinze: GT-Power
- Manuals und Tutorials GT-Power

R. Tiemann: Introduction to multi-body simulation (MBS) based on the example of the automobile
- Adamski, D., Simulation in der Fahrwerktechnik, Springer Vieweg;
- IPG documents
- Course materials
- Rill, G., Schaeffer, T., Grundlagen und Methodik der Mehrkörpersimulation
- Shabana, A., Einführung in die Mehrkörpersimulation

[*updated 04.09.2023*]

Automotive Engineering Master - optional courses

Bionics in Automotive Engineering

Module name (EN): Bionics in Automotive Engineering
Degree programme: Automotive Engineering, Master, ASPO 01.04.2023
Module code: FTM-BIO
Hours per semester week / Teaching method: 2V (2 hours per week)
ECTS credits: 3
Semester: 1
Mandatory course: no
Language of instruction: German
Assessment: Written exam, term paper [*updated 25.05.2021*]
Applicability / Curricular relevance: FTM-BIO (P242-0101) Automotive Engineering, Master, ASPO 01.04.2021 , semester 1, optional course FTM-BIO (P242-0101) Automotive Engineering, Master, ASPO 01.04.2023 , semester 1, optional course
Workload: 30 class hours (= 22.5 clock hours) over a 15-week period. The total student study time is 90 hours (equivalent to 3 ECTS credits). There are therefore 67.5 hours available for class preparation and follow-up work and exam preparation.
Recommended prerequisites (modules): None.
Recommended as prerequisite for:
Module coordinator: Prof. Dr.-Ing. Hans-Joachim Weber
Lecturer: Prof. Dr.-Ing. Hans-Joachim Weber [*updated 20.12.2021*]
Learning outcomes: After successfully completing this module, students will have an overview of what bionics can do. They will be able to identify analogies between nature and technology and learn ways to implement and apply them in simple cases. Students will be familiar with the possibilities of bionic design optimization and will be able to

apply them to simple cases.

[*updated 25.05.2021*]

Module content:
Insight into bionics, history of bionics
Construction bionics: Materials, composites, bonding, targeted adhesion and release, locomotion (walking, robotics, in water and air), nanobionics, process bionics, information bionics.
Organizational bionics, evolutionary bionics
Design optimization
The search for bionic solutions

[*updated 25.05.2021*]

Recommended or required reading:
W. Nachtigall - Das große Buch der Bionik;
Mattheck - Die Körpersprache der Bauteile;
J. Zrzavý, D. Storch S., Mihulka - Evolution

[*updated 25.05.2021*]

Entrepreneurship in Engineering

Module name (EN): Entrepreneurship in Engineering

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-ENT

Hours per semester week / Teaching method:
3V (3 hours per week)

ECTS credits:
3

Semester: 1

Mandatory course: no

Language of instruction:
German

Assessment:
Project with final presentation

[*updated 25.05.2021*]

Applicability / Curricular relevance:

FTM-ENT (P242-0102) Automotive Engineering, Master, ASPO 01.04.2021 , semester 1, optional course
FTM-ENT (P242-0102) Automotive Engineering, Master, ASPO 01.04.2023 , semester 1, optional course

Workload: 45 class hours (= 33.75 clock hours) over a 15-week period. The total student study time is 90 hours (equivalent to 3 ECTS credits). There are therefore 56.25 hours available for class preparation and follow-up work and exam preparation.
Recommended prerequisites (modules): None.
Recommended as prerequisite for:
Module coordinator: Prof. Dr. Jörg Hoffmann
Lecturer: Prof. Dr. Jörg Hoffmann [*updated 20.12.2021*]
Learning outcomes: After successfully completing this module, students will be familiar with the challenges connected to a problem-oriented development approach and will be able to analyze and evaluate them. They will be able to evaluate and derive an economic enterprise from this approach. In addition, they will be familiar with modern alternative development approaches, such as the Design Thinking Process or the Blue Ocean Strategy, and will be able to merge these with the problem-oriented development approach. They will be able to create practice-oriented pitch decks and business plans. Students will have a general overview of the basics of business administration and project management, as well as various tools for entrepreneurship in engineering, and will be able to assess and apply their areas of application and potential. [*updated 25.05.2021*]
Module content: Innovation management (Innovation strategies, impulses for innovations, innovation processes) Generating ideas/concepts according to the principle of Design Thinking/ Design Sprint process, basics of Systematic Incentive Thinking (SIT) and the Ikigai concept, insight into the problem-oriented development approach in engineering. Market and competitor analysis Developing a cost model (design to cost) Developing a business model Principles of the institutional role model (economic and technical roles) Corporate financing Types of and the significance of entrepreneurship Principles of starting a business Establishing and expanding a company Basics of personnel management and leadership Basics for the development of marketing and sales strategies Market entry, marketing and positioning Company exit Conducting lessons learned sessions [*updated 25.05.2021*]

Teaching methods/Media:
Lecture with labs and workshops

[*updated 25.05.2021*]

Recommended or required reading:

Alexander Osterwalder, Yves Pigneur et al.: Business Model Generation: Ein Handbuch für Visionäre, Spielveränderer und Herausforderer

Vanja, S. (2019), CAx für Ingenieure: Eine praxisbezogene Einführung

Michael Lewrick, Patrick Link, Larry Leifer et al.: Das Design Thinking Playbook: Mit traditionellen, aktuellen und zukünftigen Erfolgsfaktoren

Hauschildt, J., Salomo, S., Schultz, C., & Kock, A. (2016). Innovationsmanagement. Vahlen.

Vahs, D., & Brem, A. (2013). Innovationsmanagement: Von der Idee zur erfolgreichen Vermarktung (4. Ausg.). Stuttgart: Schäffer-Poeschel Verlag.

Eversheim, W., Schuh, G., Integrierte Produkt- und Prozessgestaltung

[*updated 25.05.2021*]

Experiment Design and Quality Control

Module name (EN): Experiment Design and Quality Control

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-VUQ

Hours per semester week / Teaching method:
2V (2 hours per week)

ECTS credits:
3

Semester: according to optional course list

Mandatory course: no

Language of instruction:
German

Assessment:
Composition

[*updated 04.11.2020*]

Applicability / Curricular relevance:

FTM-VUQ Automotive Engineering, Master, ASPO 01.04.2021 , optional course, technical
FTM-VUQ Automotive Engineering, Master, ASPO 01.04.2023 , optional course, technical
MAM.2.1.2.29 (P241-0367) Engineering and Management, Master, ASPO 01.10.2019 , optional course, technical
MAM.2.1.2.29 (P241-0367) Engineering and Management, Master, ASPO 01.10.2024 , optional course, technical

Workload:
30 class hours (= 22.5 clock hours) over a 15-week period.
The total student study time is 90 hours (equivalent to 3 ECTS credits).
There are therefore 67.5 hours available for class preparation and follow-up work and exam preparation.

Recommended prerequisites (modules):
None.

Recommended as prerequisite for:

Module coordinator:
Prof. Dr. Gerald Kroisandt

Lecturer: Prof. Dr. Gerald Kroisandt

[*updated 23.03.2020*]

Learning outcomes:
After successfully completing this module and based on the statistical knowledge they acquired in MAM_19_A_1.01.MTS, students will be able to determine confidence intervals for a wide range of mean values and variances. They will also understand how process control charts work.
Students will understand tests, and in particular how to proceed when choosing a hypothesis and an alternative.

As with confidence intervals, they will be able to design appropriate tests for a wide range of situations.
If something depends on several factors, e.g. the load capacity of a component, students will be familiar with common methods for designing experiments and will be able to apply them.

The question as to which factor(s) produce differences in quality is examined by analysis of variance, which students will also be able to apply.

- Point estimator (ML estimator) and mean-squared error for quality assessment

[*updated 04.11.2020*]

Module content:

- Confidence intervals for diverse situtaions
- Basics of process control charts
- Hypothesis testing for different situations
- Designing experiments
- Analysis of variance

[*updated 04.11.2020*]

Recommended or required reading:

[*still undocumented*]

Failure Analysis in Operational and Manufacturing Environments

Module name (EN): Failure Analysis in Operational and Manufacturing Environments
Degree programme: Automotive Engineering, Master, ASPO 01.04.2023
Module code: FTM-SABF
Hours per semester week / Teaching method: 1V (1 hour per week)
ECTS credits: 2
Semester: according to optional course list
Mandatory course: no
Language of instruction: German
Assessment: Term paper [*updated 01.10.2020*]
Applicability / Curricular relevance: FTM-SABF (P241-0363) Automotive Engineering, Master, ASPO 01.04.2021 , optional course, engineering FTM-SABF (P241-0363) Automotive Engineering, Master, ASPO 01.04.2023 , optional course, engineering MTM.SBF (P241-0363) Mechatronics, Master, ASPO 01.04.2020 , optional course MAM.2.1.2.15 (P241-0363) Engineering and Management, Master, ASPO 01.10.2013 , semester 1, optional course MST.SBF Mechatronics and Sensor Technology, Master, ASPO 01.04.2016 , optional course MST.SBF Mechatronics and Sensor Technology, Master, ASPO 01.10.2011 , optional course
Workload: 15 class hours (= 11.25 clock hours) over a 15-week period. The total student study time is 60 hours (equivalent to 2 ECTS credits). There are therefore 48.75 hours available for class preparation and follow-up work and exam preparation.
Recommended prerequisites (modules): None.
Recommended as prerequisite for:
Module coordinator: Prof. Dr. Moritz Habschied
Lecturer: Prof. Dr. Moritz Habschied

[*updated 20.12.2021*]

Learning outcomes:
After successfully completing this course, students will be able to use their knowledge about damage mechanisms to:
- apply the guidelines and procedures for clarifying faults and material-related manufacturing difficulties
- define the procedure for the analysis and modify it based on interim results.

- select the procedures to be applied and anticipate possible results.

- interpret the results in the context of relevant literature, the circumstances and research results.

- determine the primary cause of faults.

- giveing advice on how to avoid faults.

[*updated 01.10.2020*]

Module content:
- Systematic approach according to relevant literature and VDI guidelines
- Mechanical material testing
- Metallography
- REM and EDX analysis
- X-ray diffraction
- Material databases
- Discussion about the students´ results and reports

[*updated 01.10.2020*]

Teaching methods/Media:
Interactive lecture

[*updated 01.10.2020*]

Recommended or required reading:
Broichhausen, Schadenskunde
VdEh, Erscheinungsformen von Rissen und Brüchen
Lecture notes
K.-H. Schmitt-Thomas, Schadensanalytik
VDI-Richtlinie 3822

[*updated 01.10.2020*]

Fibre-Reinforced Composites: Calculation and Praxis

Module name (EN): Fibre-Reinforced Composites: Calculation and Praxis

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-FBP

Hours per semester week / Teaching method:

1V+3PA (4 hours per week)

ECTS credits:
5

Semester: 1

Mandatory course: no

Language of instruction:
German

Assessment:
Term paper with presentation

[*updated 28.04.2023*]

Applicability / Curricular relevance:

FTM-FBP (P241-0345) Automotive Engineering, Master, ASPO 01.04.2021 , semester 1, optional course
FTM-FBP (P241-0345) Automotive Engineering, Master, ASPO 01.04.2023 , semester 1, optional course
MAM.2.1.2.21 (P241-0345) Engineering and Management, Master, ASPO 01.10.2013 , semester 2, optional course, technical

Workload:
60 class hours (= 45 clock hours) over a 15-week period.
The total student study time is 150 hours (equivalent to 5 ECTS credits).
There are therefore 105 hours available for class preparation and follow-up work and exam preparation.

Recommended prerequisites (modules):
None.

Recommended as prerequisite for:

Module coordinator:
Prof. Dr. Moritz Habschied

Lecturer: Prof. Dr. Moritz Habschied

[*updated 21.02.2023*]

Learning outcomes:
This module is geared towards students in the Master´s degree program who are interested in gaining in-depth insight into lightweight construction.
The central question behind the project work is: "Why lightweight is often more difficult" This refers to the challenges of lightweight material construction.
To this end, students will learn about and evaluate the concepts of multi-material lightweight construction.
In the practical part of the course, a load-bearing structure will be developed and ultimately manufactured in the plastics laboratory (of the Materials Science Laboratory) under given constraints using simulation tools.
Depending on the number of participants, the practical part will take place in small groups in the form of a competition.
The knowledge gained in the process will be evaluated within the group and in comparison with the other groups, and the results will be presented.

The methodology and approach will be assessed.
Learning outcomes:
Knowledge of fibre composite construction methods with plastic matrix, as well as their manufacturing processes and areas of application
Manufacturing processes and their practical application in the project
Understanding the influence of ply and fiber structure on component properties through destructive testing
Calculating fiber volume contents and theoretical component properties (rule of mixtures)
Knowledge of different failure modes

[*updated 28.04.2023*]

Module content:
Introduction of anisotropic materials and representation of specific properties in Ashby Maps
Demonstrating the areas of application of fiber composites
Basics for the construction of fiber-matrix systems
Richmann s mixing rule and component properties
Presentation of the different types of fibers used industrially (glass/carbon/aramid fibres), presentation and comparison of the properties, as well as the manufacturing processes.
Explanation of the different matrix types thermoset, thermoplastic, elastomer
Presentation of preforming processes and the respective semi-finished products (scrims, woven fabrics, braids, winding, prepregs)
Introduction to modern production processes such as RTM, VARI, VAP and autoclave
An outlook on the potential of the materials and on current research areas, repair possibilities, as well as disposal challenges
Carrying out laboratory tests to determine material and component properties with calculation and destructive testing

[*updated 28.04.2023*]

Teaching methods/Media:
Interactive lecture with seminar units and practical units in plastics construction, supervised lab exercises in small groups with test and report.

[*updated 28.04.2023*]

Recommended or required reading:
Recommended literature will be announced during the introductory lecture.

[*updated 28.04.2023*]

IT and TC Law

Module name (EN): IT and TC Law

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-ITR

Hours per semester week / Teaching method:
2V (2 hours per week)

ECTS credits: 3
Semester: 1
Mandatory course: no
Language of instruction: German
Assessment: Written exam 120 min. [*updated 26.02.2018*]
Applicability / Curricular relevance: FTM-ITR Automotive Engineering, Master, ASPO 01.04.2021 , semester 1, optional course FTM-ITR Automotive Engineering, Master, ASPO 01.04.2023 , semester 1, optional course KIM-ITR (P222-0056) Computer Science and Communication Systems, Master, ASPO 01.10.2017 , semester 2, mandatory course PIM-ITR (P222-0056) Applied Informatics, Master, ASPO 01.10.2017 , semester 2, optional course, not informatics specific
Workload: 30 class hours (= 22.5 clock hours) over a 15-week period. The total student study time is 90 hours (equivalent to 3 ECTS credits). There are therefore 67.5 hours available for class preparation and follow-up work and exam preparation.
Recommended prerequisites (modules): None.
Recommended as prerequisite for:
Module coordinator: RA Cordula Hildebrandt
Lecturer: RA Cordula Hildebrandt [*updated 26.07.2022*]
Learning outcomes: Students will be able to apply essential legal terms and legal norms in day-to-day IT/telecommunications work. In addition to general content such as copyright and trademark law, contract law, data and customer protection ordinances, this includes IT/TC-specific content such as telecommunications law, software law and Internet law. Students will be capable of analyzing the interrelationships and applicability of the various regulations and laws in the field of information technology and using examples be able to apply them to typical situations. [*updated 26.02.2018*]

Module content:
1. Domain law
2. Copyright law
3. Open source software
4. Trademark law
5. Impressum (Imprint (UK), Site notice (USA))
6. Contract law: concluding a contract on the Internet
7. GTC law
8. Project agreement
9. Written form, electronic signature, responsibility
10. Distance selling, right of withdrawal
11. Data protection
12. Advertising
13. Telecommunications law
14. Product liability

One method of teaching the legal topics will be to use the classic example of a website with an online shop.

[*updated 26.02.2018*]

Recommended or required reading:
http://bundesrecht.juris.de/aktuell.html
(Gesetzestexte, BGB)

http://www.jurawelt.de/
see "Studentenwelt" (Skripte, Zivilrecht)

http://www.uni-muenster.de/Jura.itm/hoeren/
see "Lehre", "Materialien", Skriptum Internet-Recht

[*updated 26.02.2018*]

Systems Engineering and Modern Simulation Methodologies

Module name (EN): Systems Engineering and Modern Simulation Methodologies

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-SEMS

Hours per semester week / Teaching method:
-

ECTS credits:
3

Semester: 2

Mandatory course: no

Language of instruction:
German

Assessment:
Oral exam

[*updated 30.10.2023*]

Applicability / Curricular relevance:

FTM-SEMS (P242-0125) Automotive Engineering, Master, ASPO 01.04.2021 , semester 2, optional course
FTM-SEMS (P242-0125) Automotive Engineering, Master, ASPO 01.04.2023 , semester 2, optional course

Workload:
The total student study time for this course is 90 hours.

Recommended prerequisites (modules):
None.

Recommended as prerequisite for:

Module coordinator:
Prof. Dr.-Ing. Rüdiger Tiemann

Lecturer:
M.Eng. Julian Riedel

[*updated 21.08.2023*]

Learning outcomes:
Excursus: After successfully completing this module, students will be familiar with trends in the on-board network architecture of modern vehicles and their requirements, resulting from the architecture itself and future mobility concepts.

Part 1: Systems Engineering
- Students will understand the interdisciplinary approach to develop and implement complex, technical systems in large projects
- By understanding the importance of traceability, traceability and coordination, students will be able to solve problems using systems engineering approaches
- Students will be able to to derive and formulate requirements at various levels in order to reflect these requirements in the development process

Part 2: Modern Simulation Methodologies
- Students will be able to apply methodologies for development and validation with the help of (co-)simulations
- By becoming familiar with two tools prominent in the automotive industry (IPG CarMaker and Typhoon HIL) and using their knowledge of requirements for simulations, students will be able to formulate goals, as well as methodologies for implementation and ultimately realize a co-simulation

[*updated 30.10.2023*]

Module content:
Excursus: Requirements for modern onboard networks and the shift towards zone control units in the context of Software Defined Vehicles

Part 1: Systems Engineering (SE)
- Repetition: V-model + Introduction Z-model
- Coupling the V-model to development levels with requirements
- Examples for the implementation of traceability
- Introduction to system architecture and modeling (SysML)
- Examples for the development of a vehicle feature

Part 2: Modern Simulation Methodologies
- Importance and requirements of co-simulations based on a practical example
- Methodologies and implementation for the creation of co-simulation
- Requirements for real-time simulations
- IPG CarMaker and Typhoon HIL as a software package for the simulation of a complete battery electric vehicle

[*updated 30.10.2023*]

Recommended or required reading:

[*updated 30.10.2023*]

Traffic Control and Traffic Management

Module name (EN): Traffic Control and Traffic Management

Degree programme: Automotive Engineering, Master, ASPO 01.04.2023

Module code: FTM-KVUV

Hours per semester week / Teaching method:
4V (4 hours per week)

ECTS credits:
6

Semester: 2

Mandatory course: no

Language of instruction:
German

Assessment:
Oral examination

[*updated 21.12.2023*]

Applicability / Curricular relevance:

E2936 (P222-0097) Electrical Engineering and Information Technology, Master, ASPO 01.04.2019 , semester 2, optional course, technical
FTM-KVUV (P222-0097) Automotive Engineering, Master, ASPO 01.04.2021 , semester 2, optional course
FTM-KVUV (P222-0097) Automotive Engineering, Master, ASPO 01.04.2023 , semester 2, optional course
KI833 Computer Science and Communication Systems, Master, ASPO 01.04.2016 , semester 2, optional course, telecommunications-specific
KIM-VSVM (P222-0097) Computer Science and Communication Systems, Master, ASPO 01.10.2017 , semester 2, optional course, telecommunications-specific
MAM.2.1.4.10 (P222-0097) Engineering and Management, Master, ASPO 01.10.2013 , semester 2, optional course, technical
PIM-WI77 Applied Informatics, Master, ASPO 01.10.2011 , semester 2, optional course, informatics specific
PIM-VSVM (P222-0097) Applied Informatics, Master, ASPO 01.10.2017 , semester 2, optional course, informatics specific

Workload:
60 class hours (= 45 clock hours) over a 15-week period.
The total student study time is 180 hours (equivalent to 6 ECTS credits).
There are therefore 135 hours available for class preparation and follow-up work and exam preparation.

Recommended prerequisites (modules):
None.

Recommended as prerequisite for:

Module coordinator:
Prof. Dr. Horst Wieker

Lecturer: Prof. Dr. Horst Wieker

[*updated 20.12.2021*]

Learning outcomes:
After successfully completing this module, students will be able to correctly classify traffic control and traffic management methods and procedures.

They will be able to describe the requirements and challenges of traffic control from an operational point of view.

Students will be able to apply the traffic flow theory to traffic control procedures. In doing so, they will be able to evaluate urban traffic disturbances and highway traffic control correctly in order to be able to make recommendations for control procedures. Students will also be able to take the operational view of traffic into account.

In addition, students will be capable of applying methodological approaches and explaining the data standards used.

Students will be able to describe the technical requirements of cooperative systems (Car2X) on the infrastructure and be able to assign them to vehicle-related applications.

The goal of this module is to enable students to analyze future development trends in traffic management and assess their effects.

[*updated 26.02.2018*]

Module content:

1. Definition of traffic management and traffic control and the differentiation between urban and suburban areas
2. Extra-urban traffic control systems
3. Urban traffic control systems
4. Traffic management
5. Extra-urban data standards
6. Urban data standards
7. Planning process and planning tools
8. Integrated traffic management, strategy management
9. Telematics, vehicle-related applications
10. Infrastructure quality in Germany
11. Infrastructure quality ROW and in particular, USA
12. Car2X and Car2Car, application overview
13. Car2X demands on traffic infrastructure
14. Intermodal traffic management
15. Outlook/Development trends in traffic management and control

[*updated 26.02.2018*]

Recommended or required reading:

[*updated 21.12.2023*]