Stuttgart International Summer School • Mobility
25 June – 11 July 2018

System Competence in Electric, Hybrid and Combustion Powertrains, Aerodynamics and Aeroacoustics

Steegmann / FKFS

Schedule

Course 1	25 – 27 June 2018[1]	**System Integration, Simulation and Energy Management of Hybrid Electric Vehicles**
Course 1a	25 June 2018[2]	**Overview of System Integration, Simulation and Energy Management of Hybrid Electric Vehicles**
Course 2	2 – 4 July 2018[1]	**Energy Storage Systems for E-Mobility**
Course 2a	2 July 2018[2]	**Overview of Energy Storage Systems for E-Mobility**
Course 3	9 – 11 July 2018[1]	**Vehicle Aerodynamics and Aeroacoustics**

[1] Day 1 + 2: 8:30 – 17:30, Day 3: 8:30 – 16:00
[2] Day 1: 8:30 – 17:30

Registration Fee

Course 1 / 2 / 3: **1.900 € + VAT**
Course 1a / 2a (Overview Courses): **950 € + VAT**
Course 1 and 2 together: **3.400 € + VAT**
Courses 1 and 2 can be taken stand-alone or in sequence.

Group Discounts:
2 participants of the same organization registering at the same time: 10 % discount.
3 participants of the same organization registering at the same time: 15 % discount.

The registration fee includes:
- A comprehensive set of notes
- Lunch, cold drinks and coffee at break times
- Access to a social evening

Registration

Sign up now: www.stuttgart-summerschool.de/registration
Registrations until 28 May 2018 (thereafter subject to availability).

Logistics

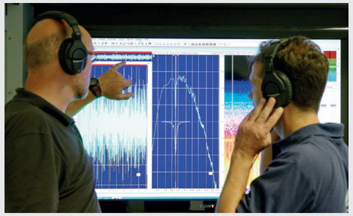
Location:
FKFS, Pfaffenwaldring 12, 70569 Stuttgart, Germany

Accommodation:
Conference hotel campus.guest, Universitätsstraße 34, 70569 Stuttgart, Germany
www.campus-guest.de
Please make your own reservations. Room allotment available until 14 days before start of course. Reservation keyword: Summer School Course.

Format and Delivery Method:
Each course is a non-credit graduate level seminar consisting of lectures and exercises or lab sessions.

Materials:
A comprehensive set of notes will be provided on the first day of the course.

Social Evening:
On the first or second evening of the course there will be a social get-together during which the participants of the Stuttgart International Summer School will have the chance to network in a relaxed and comfortable atmosphere. Taking part in the social evening is optional and included in the course fee.



FKFS Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren Stuttgart
Pfaffenwaldring 12 • 70569 Stuttgart, Germany
Christa Kolz • Phone +49 711 685-65751 • Fax +49 711 685-65710
summerschool@fkfs.de • stuttgart-summerschool.de

In cooperation with:
Universität Stuttgart

Course 1 + 1a: System Integration, Simulation and Energy Management of Hybrid Electric Vehicles

Learn HEV System Simulation Methods for SIL and HIL Development of HEV Energy Management Strategies

Course Objectives:

The objective of this course is to introduce the participants to HEV system integration and energy management concepts using modern simulation methods based on Matlab/Simulink tools. The participants will use a modular simulator compatible with software- and hardware-in-the-loop control development systems, describing the energy flows in conventional and hybrid vehicles and analyzing energy management strategies in a series of computer laboratory exercises that culminates with the participants developing their own energy management strategy based on the simulator developed during the course. Participants receive a copy of the modular Matlab/Simulink simulator used in the exercises.

Objective 1: (Courses 1 + 1a)
Evaluate energy consumption in road vehicles. Relate energy demand of driving cycles to fuel economy and CO_2 emissions. Understand the concept and potential benefits of drivetrain hybridization strategies.

Objective 2: (Course 1)
Develop mathematical models of energy use in combustion engine and mechanical transmission subsystems and use these models in a vehicle simulator to predict fuel consumption and CO_2 emissions.

Objective 3: (Course 1)
Develop mathematical models of electric traction drives and energy storage systems, used in hybrid vehicles. Use these models in electric and hybrid vehicle simulators to predict energy use and CO_2 emissions.

Objective 4: (Course 1)
Learn principles of energy management for hybrid electric vehicles, including mathematical methods such as Dynamic Programming, as well as real-time implementable strategies such as ECMS. Explore and improve HEV supervisory control design and energy management using a hybrid-electric vehicle simulator.

Giorgio Rizzoni at the OSU Center for Automotive Research

The Ohio State University PHEV prototype, winner of the 2015-2018 EcoCAR 3 competition

For a more detailed description of the course please visit www.stuttgart-summerschool.de

Goals:

Upon completion of the course the participants will be familiar with energy analysis and modeling of hybrid-electric powertrains, with some principles of optimal control, with Matlab/Simulink™ tools for vehicle energy analysis and supervisory control, and with the design of energy management strategies using StateFlow™.

Lecturer:

Prof. Giorgio Rizzoni, The Ohio State University
Giorgio Rizzoni, the Ford Motor Company Chair in ElectroMechanical Systems, is a Professor of Mechanical and Aerospace Engineering and of Electrical and Computer Engineering at The Ohio State University (OSU). He received his B.S. (ECE) in 1980, his M.S. (ECE) in 1982, his Ph.D. (ECE) in 1986, all from the University of Michigan. Since 1999 he has been the director of the Ohio State University Center for Automotive Research (CAR), an interdisciplinary research center in the OSU College of Engineering. He is author or co-author of 500 journal and conference papers, and three books. He is a Fellow of SAE (2005), a Fellow of IEEE (2004), a recipient of the 1991 National Science Foundation Presidential Young Investigator Award.

Course 2 + 2a: Energy Storage Systems for E-Mobility

Learn Lithium Ion Battery Technology and Energy Storage Systems for Electrified Vehicles

Course Objectives:

The course introduces the participants to energy storage systems for electrified vehicles based upon lithium ion battery technology. The course is designed to provide engineers and managers in the automotive industry with a broad overview on the subject, covering multiple areas such as cell materials and fundamental properties, testing procedures for performance characterization, modeling and simulation, system integration, control, diagnostics and prognostics. The course is a combination of lectures, case studies and computer laboratory exercises. During the laboratory sessions, the participants will utilize Matlab/Simulink tools to design and calibrate a lithium ion battery model, develop a state-of-charge estimation algorithm and a simple strategy for battery pack charging and balancing.

Objective 1: (Courses 2 + 2a)
Explore the state of the art of lithium ion batteries for automotive applications, their operating principles, materials, and future directions of technical development.

Objective 2: (Courses 2 + 2a)
Learn the experimental methods required to characterize the performance of batteries

Objective 3: (Course 2)
Develop mathematical models that predict the performance (dynamic voltage-current relationship) of lithium ion batteries and the mechanisms that lead to capacity and power fade.

Objective 4: (Course 2)
Learn principles of system integration and related issues, such as design and packaging, thermal management systems (TMS), and battery management systems (BMS) hardware and software architectures.

Objective 5: (Course 2)
Utilize mathematical models to design simple algorithms for SOC estimation, pack charging and cell balancing.

Note: You may choose to take only Day 1 for an "executive-style" overview of lithium ion battery technology (state of the art, directions of development, challenges and opportunities for the automotive industry), or the full course for delving deeper into the technical topics.

The Ohio State University Electric Motorcycle Racing at the 2017 Pikes Peak Hill Climb

For a more detailed description of the course please visit www.stuttgart-summerschool.de

Goals:

Upon completion of this course, the participants will possess practical knowledge of (1) Operating principles and characteristics of lithium-ion batteries, including the effects of electrode/electrolyte materials on performance and durability; (2) Experimental methods for characterizing performance and life of Li-ion cells, in support of modeling, design and prototype verification; (3) Modeling and simulation tools to solve system-level design and optimization problems for battery packs for EVs and HEVs; (4) Common system integration and control issues (electrical and thermal management, state estimation, etc.), and solution methods.

Lecturer:

Prof. Marcello Canova, The Ohio State University
Marcello Canova is Associate Professor of Mechanical and Aerospace Engineering at The Ohio State University, and Associate Director for Graduate and Continuing Education at the Center for Automotive Research. His research focuses on the optimization and control of propulsion systems, including internal combustion engines, hybrid-electric drivetrains, energy storage systems and thermal management. Dr. Canova's work in energy optimization of advanced powertrains has led to significant fuel economy benefits and has been implemented in production programs by major OEMs. In addition, he has published over 110 articles in refereed journals and conference proceedings and received, among others, the SAE Vincent Bendix Automotive Electronics Engineering Award (2009), the SAE Ralph E. Teetor Educational Award (2016), the NSF CAREER Award (2016), the Lumley Research Award (2016) and the Michael J. Moran Award for Excellence in Teaching (2017).

Course 3: Vehicle Aerodynamics and Aeroacoustics

Know-how in Theory, Measuring Technique and Testing

Course Objectives:

The course is designed to provide a detailed understanding of vehicle aerodynamics and vehicle aeroacoustics. The participants will be trained to be able to carry out respective development work at car manufacturers and suppliers under consideration of the various interfaces to other disciplines.

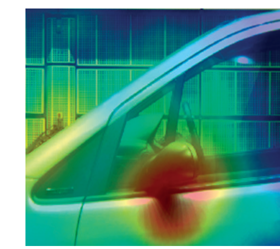
Objective 1: Understand basic aerodynamic physics and relationships; apply fundamental aerodynamic equations on standard flow situations; assess aerodynamic coefficients and aerodynamic results; influences on vehicle drag and lift as well as vehicle dynamics.

Objective 2: Understand the principal acoustic and aeroacoustic physics; choose the adequate measurement instrumentation and setup; acquire expertise to assess aeroacoustic analyses and results.

Objective 3: Understand the approaches when implementing computational methods in aerodynamics and aeroacoustics; being able to assess the possible field of application and the advantages and disadvantages concerning the various numerical methods realistically.

Objective 4: Learn to plan and conduct aerodynamic and aeroacoustic investigations under experimental conditions in our modern wind tunnel facilities (full-scale aeroacoustic and scale-model wind tunnel as well as briefly thermal wind tunnel) and to evaluate the measured data.

Experimental and numerical investigation of the flow through a rotating wheel



Measurement by array-based acoustic mirror in full-scale wind tunnel

For a more detailed description of the course please visit www.stuttgart-summerschool.de

Goals:

After having completed this course, the participants will have a fundamental knowledge about vehicle aerodynamics and aeroacoustics. They will be able to use high-tech aerodynamic and aeroacoustic measurement techniques and to carry out wind tunnel tests, both in order to effectively perform aerodynamic and aeroacoustic development work on cars and to consider the interfaces to other disciplines.

Lecturer:

Prof. Dr.-Ing. Jochen Wiedemann, University of Stuttgart
In 1977 Professor Wiedemann received his diploma degree in mechanical engineering from Ruhr-Universität, Bochum, Germany. After carrying out aerodynamic research at the von Karmàn Institute for Fluid Dynamics in Belgium and Ruhr-University Bochum he received the doctoral degree (Dr.-Ing.) in 1983 for his work on aerodynamic drag reduction. In 1984 Professor Wiedemann joined Audi AG where he held several managing positions. In 1998 Jochen Wiedemann was appointed Chair Professor of Automotive Engineering at the Institute for Internal Combustion Engines and Automotive Engineering (IVK) at Stuttgart University, Germany and he also became a Member of the Board of Management of FKFS. His research work is largely associated with aerodynamics/aeroacoustics, road load and vehicle dynamics.
Co-lecturers: Dr. Reinhard Blumrich, FKFS, Head of NVH Department, Nils Widdecke, IVK/FKFS, Head of Aerodynamics, Dr. Timo Kuthada, FKFS, Head of High Performance Computing, Dr. Felix Wittmeier, FKFS, Head of Model-Scale Wind Tunnel.