HOGESCHOOL VAN ARNHEM EN NIJMEGEN

DEPARTMENT OF AUTOMOTIVE ENGINEERING

MASTER OF AUTOMOTIVE ENGINEERING

PROGRAM OF THE 2ND YEAR

Vehicle Dynamics and Clean Driveline Control Systems

Winter semester

Topics	Termination	ECTS Credits
ADVANCED VEHICLE DYNAMICS	Ex	7
ADVANCED VEHICLE CONTROL	Ex	4
VEHICLE ELECTRONICS	Ex	5
SYSTEM CONTROL ENGINEERING	Ex	4
AUTOMOTIVE MANAGEMENT	Ex	4
INTELLIGENT VEHICLE HIGHWAY SYSTEMS	Ex	3
ALTERNATIVE POWERTRAINS	Ex	3
		30

Summer semester

Topics	ECTS Credits
FIVE MONTH INTERNSHIP	10
DIPLOMA WORK	20

ADVANCED VEHICLE DYNAMICS

Type		Compulsory	**Semester**		winter
Contact hours	84	**Number of credits**		7	
Type of termination		Exam	**Form**		Lectures + exercises

Lecturers

Prof. Dr. Ing. Joop Pauwelussen
Ing. Saskia Monsma
Ing. Karel Kural
Mr. Sander de Goede

Anotation

TARGET

The course 'Advanced Vehicle Dynamics' is a follow-up course of 'Vehicle Dynamics' offering a more in depth treatment of vehicle dynamics topics.

CONTENTS

- Tyre characteristics and non-linear vehicle performance
- Dynamic tyre behaviour
- Graphical methodologies to express vehicle dynamics performance
- Motorcycle dynamics
- Dynamics of articulated vehicles.
- The vehicle-driver interface

In contrast to the linear approach in the first course, the vehicle behaviour is now treated including the full non-linear behaviour of the tyres. This means that extreme limit behaviour can be discussed where one of the wheels is approaching (or even exceeding) the friction limits, as is the case under race and rally conditions.
The equations of motion are discussed in its full non-linear settings with emphasis on methodologies related to non-linear differential equations like phase plane analysis, non-linear stability theory (global stability and attraction of steady state points).
Another extension with respect to the first year course is the inclusion of dynamic tyre characteristics, where distinction is made between relaxation effects (first order dynamics) in combination with for example relatively fast steering, and rim-dynamics being important for the design of active control systems (see course on "Advanced Vehicle Control").
A special number of lectures will be devoted to graphical methodologies to express vehicle dynamics performance. The phase-plane approach, mentioned before, is more then a tool to visualize non-linear vehicle behaviour. It offers a very interesting interpretation of that will be explained in some detail. In addition to this type of analysis, two other graphical approaches exist, which share the advantage with the phaseplane analysis of offering a framework for the engineer that helps him to understand vehicle manoeuvring and stability problems top-down on an abstract level.
In total, we will treat:

- Phase plane analysis and vehicle performance interpretation
- Non-linear handling diagram analysis
- Stability diagram (stability in relationship with non-linear tyre characteristics).

The theory will be applied to motorcycle/racecar dynamics.
Finally, two special areas will get more attention, the dynamics of articulated vehicles and the vehicle driver interface (as an extension of the treatment of criteria of good handling performance as part of the first year course on Vehicle Dynamics).
The first area relates to car-caravan and commercial vehicle combinations, including a discussion of their behaviour and stability properties in relationship to their design properties. Not only conventional vehicle combinations but also road-trains and combinations with extreme trailer-length will be discussed. The second area refers mainly to judgement of the vehicle-driver interface, based on output parameters such as SRR: Steering Reversal Rate, HFA: High Frequency Area, and TLC: Time to Line Crossing. Some driver models will be discussed, and a driver-vehicle model for path tracking for arbitrary curve will be derived. Interpretation will be given with reference to workload, steering hysteresis characteristics and steering feel.

Again, in order to bridge the gap between theory and practical use of this theory, a number of simulation practices will be carried out by the students:

Simulation practice 1 : non-linear tyre characteristics and vehicle performance
Simulation practice II : performance of articulated vehicles (commercial vehicles, car-caravan)
Simulation practice III: path tracking and driver workload

In order to judge the student performance, a number of exercises has to be solved which are representative for the course

material.

Study materials

Lecturing materials and hand-outs

1. G. Genta.: Motor Vehicle Dynamics, World Scientific, ISBN nr. 9810229119
2. R.J. Jagacinski, J.M. Flach.: Control Theory for Humans, ISBN nr. 0805822925
3. H.B. Pacejka.: Tyre and Vehicle Dynamics, Butterworth Heinemann, Oxford (2005) ISBN nr. 0750651415
4. V. Cossalter.: Motorcycle Dynamics (2006), ISBN nr. 978 – 1 – 4303 – 0861 – 4
5. J.P. Pauwelussen.: Graphical Means to Analyze and Visualize Vehicle Handling Behaviour, ECCOMAS Thematic Conference in Multibody Dynamics 2005, Madrid
6. J.P. Pauwelussen, W. Dalhuijsen.: Tyre as a Vehicle Component, 4 ECTS module of VERT: Virtual Education in Rubber Technology. EU Leonardo project FI-04-B-F-PP-160531 (2007)
7. P.Sweatman (ed.).: PBS Explained, Performance Based Standards for Road Transport Vehicles, report

ADVANCED VEHICLE CONTROL

Type	Compulsory	**Semester**	winter
Contact hours	32	**Number of credits**	4
Type of termination	Exam	**Form**	Lectures + exercises

Lecturers

Prof. Dr. Ing. Joop Pauwelussen
Ing. Karel Kural

Anotation

TARGET

Future automotive engineers will operate in a multidisciplinary environment and this will need to be reflected in the education that they receive. Developments in the field of cars and traffic systems will make a sound understanding of dynamics and control engineering, electronics and process engineering ever more important. This development is currently shaping the image of the automotive industry, in its transition from a mechanical-engineering past to a multidisciplinary future.

The core area here encompasses dynamic system behaviour and control technology, with a prominent role for discoveries in the field of Mechatronics and the driver-vehicle interface. For this reason, attention is also given to the driver-vehicle system and modern vehicle control, with the fundamental vehicle dynamics aspects as a firm basis.

CONTENT

Introduction to vehicle control and basis of systems control engineering

- Vehicle as a system, controlled by tyre forces and internal suspension loads, with interfaces to the driver and the traffic environment.
- Driver modelling, the 'driver in the loop'
- The driver transport mission and behavioural approach
- Perception and physiological response
- ADA: Advanced Driver Support
- Workload and workload measures
- Power steering (EPS, EHPS)
- Integrated vehicle (body) control
- Suspension control
- Traction and brake control
- Advanced steering control, steer by wire

The first three topics should give the student a basic knowledge and understanding about the vehicle in relationship with its environment (traffic conditions, road- and weather conditions, the driver as the prime observer and controller). It also includes some basic control system engineering methodologies (e.g. PID control, Kalman filtering, optimal control,...), which are required to understand vehicle control strategies. Hence, the vehicle is considered as part of the total traffic and mobility system. From a control point of view, a vehicle may be considered as a collection of advanced systems, each of them being controlled separately. Another approach is more top-down, where the principal control opportunities through the tyre-road contact and the suspension performance are considered in an integrated way. Both approaches are included in the course, with reference made to many practical applications.

In order to bridge the gap between theory and practical use of this theory, a number of simulation practices will be carried out by the students:

- Simulation practice I: ESP vehicle control
- Simulation practice II: Power steering
- Simulation practice III: Closed loop vehicle performance

In order to judge the student performance, a small thesis on a collection of the topics plus an oral examination has to be completed.

Study materials

1. Lecturing material and hand-outs (Power Point, Scholar)
2. U. Kiencke, L. Nielsen.: Automotive Control Systems, chapters 8, 9 and 10. Springer-Verlag (2005), ISBN nr.: 3 – 540 – 32139 – 0

Other recommended literature

1. R.J. Jagacinski, J.M. Flach.: Control Theory for Humans, ISBN nr. 0805822925
2. H. Wallentowitz, K. Reif.: Handbuch Kraftfahrzeugelektronik, Grundlagen, Konponenten, Systeme, Anwendungen, ATZ/MTZ Fachbuch (2006), ISBN nr. 3 – 528 – 03971 – X
3. Conference proceedings such as AVEC (Advanced Vehicle

VEHICLE ELECTRONICS

Type		Compulsory	**Semester**		winter
Contact hours	58	**Number of credits**		5	
Type of termination		Exam	**Form**		Lectures + exercises

Lecturers

Dr. Stefan van Sterkenburg
Mr. Paul de Bruijn
Mr. Ino de Gijsel

Anotation

TARGET

The subsequent changes in the Automotive Industry have a follow-up time which is getting smaller and smaller. Consequently, the applied automotive electronic systems must, and will change even faster. This requires a skilled staff with specialized know-how and understanding in the specific area of automotive electronics. For this reason, this area will get much attention within this Master Degree of Automotive Engineering. This course can be considered as a follow-up course on microelectronics and autronics in the first semester.

The present course consists of two major parts, a theoretical parts comprising 60 % of the time, and a practical part comprising 40 % of the time. Demonstrations and assignments will be carried out during the course. The course has a strong input from the Automotive industry (SME's and larger companies) such that the practical use of this course for automotive application is guaranteed.

Objective of this course is to establish the know-how and understanding on the functionality of motor management systems and the (chassis) electronic subsystems, components, sensors etc. and to gain a comprehensive understanding of micro-controllers and electronic devices and corresponding terminology related to these subjects. In addition, attention is given to the monitoring of electronic devices, analysis and cancelling of failures.

The course approaches automotive electronics at three different levels:

- System level
- components
- applied technologies

At system level, the emphasis is on process control, the interaction between subsystems and/or components. At component level, emphasis will be on the electrical and electronic principles as part of the components applied in the (sub-)systems.

CONTENT

Electronic systems:

- Motormanagement systems (petrol, diesel)
- Electronically controlled transmission
- Electronic chassis control

Electronic components:

- Sensor technologies
- Automotive sensors
- Automotive actuators
- Electronic interfaces
- Power electronics
- Microcontrollers

Applied technologies:

- Introduction into the programming of microcontrollers
- Introduction into the digital monitoring and control technologies
- Intersystem communication and multiplex systems
- Reliability and diagnostics

A number of practical assignments will be carried out by the students:

- assignment 1: sensors
- assignment 2: actuators
- assignment 3: interface electronics
- assignment 4: input capture and output compare timers

Study materials

1. Lecturing material and hand-outs (Power Point, Scholar)
2. A. Visser.: Reader Vehicle Electronics, nr. 5417

SYSTEM CONTROL ENGINEERING

Type	Compulsory	**Semester**	winter
Contact hours 58	**Number of credits**	4	
Type of termination	Exam	**Form**	Lectures + exercises

Lecturers

Dr. Bram Veenhuizen
Mr. Egon Haffmans

Anotation

TARGET

This course on systems control engineering has been designed to offer the necessary tools for the Automotive Engineer to understand the problems of intelligent vehicle and traffic performance from a system point of view.

CONTENT

- **Mathematics**, complex variables, Laplace transforms, etc.
- **Introduction to control engineering**, transfer functions and block diagrams, behaviour of linear systems, concept of feedback control, stability and steady state errors
- **Frequency domain design**, system representation, closed loop stability, Bode and Nyquist diagrams, controllers
- **Modelling and simulation** including some laboratory work (exercise), transfer function, state space representation
- **Root locus design**, pole location and damping, settling time and overshoot, feedback and pole location, root locus of closed loop systems
- **Measurement and sensors**, measurement accuracy, dataprocessing, signal transmission and adaptation,…
- **Process control**, dynamics, components, single loop feedback control systems, tuning, cascade control, override and selective control, ratio and feed forward control
- **Multivariable / State Space Design**, mimo systems, multivariable systems in state space
- **Servo Mechanisms**, servomotor types and characteristics, load characteristics, dynamic behaviour of motor and load, transmission and reflected inertia
- **Digital Control Systems**, discrete time models, z-transformation of a system,..
- **Optimal and adaptive control**, observers and state estimation, operability and controllability, model identification,…
- **Statistical Process Control**
- **Batch control**

In addition to the lectures, two laboratory sessions are scheduled as part of the course:

- **Control engineering laboratory 1**, process identification and simulation, controller tuning
- **Control engineering laboratory 2**, control valve actuator, valve characteristics, valve positioner, process simulator

A special workshop on Matlab/Simulink will be part of the curriculum.

Study materials

1. Lecturing material and hand-outs (Power Point, Scholar)
2. N.S. Nise.: Control Systems Engineering, 3rd edition, John Wiley & Sons (2000), ISBN nr.: 0 471 36601 3

AUTOMOTIVE MANAGEMENT

Type	Compulsory	**Semester**	winter
Contact hours 32		**Number of credits**	4
Type of termination	Exam	**Form**	Lectures + exercises

Lecturers

Mr. Pieter van Baardwijk

Anotation

TARGET

The automotive industry has shown major changes in the last couple of years. More and more, the technological innovations have impact on the management of automotive companies (not only the OEMs but also first tier supplier, second tier supplier etc.) , and vice versa. On the other hand, the globalisation and the ever increasing pressure on cost-levels and time-to-market strongly determine the way research and development processes are shaped between manufacturers and their suppliers. Topics like co-design and co-manufacturing, virtual prototyping, just-in-time, supply chain management, total quality management etc describe well-established and recognised values within the automotive society, and every engineer working in this field has to be aware of these developments and trends.

CONTENT

The course on Automotive Management will address most of these aspects, with emphasis on the string interdependency of technical innovations and organisation (and management).
Modifications in the automotive industry are not just consequences by the need to reduce costs. Due to globalisation, modularisation of the design is a requirement, in relationship with a logistic chain approach, and accounting for socio-economic pressure (e.g. Kyoto agreement). The Automotive Industry sees changes in the way the customer decides about his/her new car. Customisation becomes important, a large variation for a relatively small batch of products for a single design.
Tools that are required here include TQM (oriented both on product and process), thinking in systems, concurrent engineering, life cycle analysis, etc.
A new vehicle means a new design and development, and a new production process. These processes rely more and more on virtual design tools (CAD, CAE, rapid prototyping) with a strong impact for the digital information management and communication within the company and between companies.

All of these aspects will be discussed within this course, within the framework of the so-called seven S-conceptual model by McKinsey, with the Ss related to:

- Strategy
- Structure
- Systems
- Style (management-)
- Staff
- Skills
- Shared Values

The students will carry out a small project where he/she has to analyse an automotive organisational problem and suggest a strategic change, as well as the process to move from the present Ist-situation to the new Soll-situation (strategy priority, implementation, acceptance of the organisation,…)

Study materials

1. Lecturing material and hand-outs (Power Point, Scholar)
2. Journals like: Automotive Engineering and AutoTechnology.
3. Automotive management “Strategie und Marketing in der Automobilwirtschaft“. Springer Verlag, ISBN nr. 354000226X
4. P. and N. Atwood.: Logistics of a distribution system. Gower Publishing Company (1992), ISBN nr. 566090988

5. S. Newburry.: The car design yearbook, Merrell Publishers Limited, London (2002)
6. O. van Fersen.: Ein Jahrhunderd Automobiltechnik,

INTELLIGENT VEHICLE HIGHWAY SYSTEM

Type	Compulsory	**Semester**	winter
Contact hours	20	**Number of credits**	3
Type of termination	Exam	**Form**	Lectures + exercises

Lecturers

Dr. Ing. Frans Tillema

Anotation

TARGET
The automotive engineer has to consider the vehicle as part of an advanced traffic system. Vehicle design is not an isolated problem anymore. Performance in terms of safety, environmental impact and efficiency relies essentially on the traffic environment, especially with reference to all kinds of new trends related to automated vehicle guidance.

This course aims to treat vehicle design within the framework of an intelligent traffic system. The focus is still on the vehicle, i.e. the course will not deal with traffic management , but the surrounding traffic partners, the infrastructure, the driver (as controller, but also as a navigator) will play a crucial role in this course.

CONTENT

- Tracking control, with the vehicle-driver system finding its way (semi-) automatically, with or without support of the driver along a certain path. Both path-following and optimal path design (for example in case of overtaking or merging in an automated platoon)
- Automated vehicle guidance, with a discussion of recent developments, including topics like intelligent merging, ACC/stop and go, with chain stability taken into account
- ADA systems, especially focussing on the increasing amount of support systems inside the cabin, and its impact in driver attention, safety, etc.
- Local area and global area mobile communication
- Support of elderly and handicapped drivers
- Lane departure warning systems
- Intelligent logistics and chain management
- Special examples of Automated Guided Vehicles, cyber cars and people movers.
- Object recognition (traffic signs, passing pedestrians,..) and classification
- Collision warning and avoidance

In order to judge the student performance, a small thesis on a collection of the topics plus an oral examination have to be completed.

Study materials

1. Lecturing Materials and Hand-outs
2. R. Bishop.: Intelligent Vehicle Technology and Trends, Artech House, ISBN nr. 1 – 58053 – 911 – 4

ALTERNATIVE POWERTRAINS

Type	Compulsory	**Semester**	winter
Contact hours 42		**Number of credits**	3
Type of termination	Exam	**Form**	Lectures + exercises

Lecturers

Prof. Dr. Ing Bram Veenhuizen
Dr. Ing. Hans Bosma
Dr. Stefan van Sterkenburg

Anotation

TARGET

The world still heavily depends on conventional fuels (petrol, fuels), originating from politically unstable areas in the world. Due to the fast economic developments in China and India, the energy consumption will double in size in the next decades, and likewise the greenhouse gases and the toxic local emissions due to the increasing road traffic.

As a result, much effort is put in the development of cleaner vehicles, with focus on synthetic fuels, biofuels (ethanol, DME, …), natural gas, hybrid vehicles, electrical vehicles, hydrogen, etc. Hence, there is a large variety of activities going on, and this course will discuss these development from an in-depth technological but also socio-economic point of view.

CONTENT

- Introduction hybridization of vehicles, fundamentals of hybrid electrical vehicle (HEV) powertrain
- Advanced architecture of HEV and dynamics of HEV power train
- Electric machines
- Energy storage
- Analysis of fuel consumption of HEV in city drive and highway drive without use of electric propulsion
- Analysis equivalent fuel consumption HEV at CD an CS operation mode
- Influence of different EMS, optimization utility factor by varying battery and electric motor characteristics

In-depth treatment of the various technical concepts.

- What has been achieved so far , clean vehicles that have been introduced to certain markets
- Developments at the middle and long term (biofuels, hydrogen)
- Developments at the short term (hybrid, natural gas, electric, improved diesels,..)
- Examples of HEV vehicles

In order to judge the student performance, a small thesis on a collection of the topics plus an oral examination have to be completed.

Study materials

Lecturing material and hand-outs
Chris Mi, a.o; Hybrid Electric Vehicles; Wiley; ISBN 978-0-470-74773-5