**COURSE DESCRIPTION CARD - SYLLABUS**

Course name
Vehicle dynamics fundamentals and control
**Course**

Field of study
Mechanical Engineering (Erasmus Plus)
Area of study (specialization)
-
Level of study

Form of study

Year/Semester
2/3
Profile of study

Course offered in
english
Requirements

 **Number of hours**

Lecture
0
Tutorials
0
Laboratory classes
15
Projects/seminars
0
Other (e.g. online)
0

**Number of credit points**6

**Lecturers**

Responsible for the course/lecturer:
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 61-138 Poznan, Poland

Ph: + 48 61-665 22 22Responsible for the course/lecturer:

 **Prerequisites**
Knowledge: Basic knowledge of mathematics and technical mechanics.

Skills: The student Is able use the languages: native and international at a level sufficient to enable understanding of technical texts. Is able to obtain information from the literature, internet, databases and other sources. Can integrate the information to interpret and learn from them, create and justify opinions. The student is able to use learned mathematical and physical theories to build and analyze of simple mathematical models of vehicle dynamics.

Social competences: The student is creative and consistent in the implementation of tasks, shows independence in solving problems, acquiring and improving the acquired knowledge and skills. Understands the need and knows the possibilities of lifelong learning..

**Course objective**
The aim of the course is to present knowledge about the mechanics of vehicle motion and to provide the ability to interpret the relationship between the excitations and vehicle motion and their performance with the use of simulation tools. The scope of knowledge includes issues discussing the relationship between the design parameters and the dynamic properties of the vehicle in the areas of acceleration ability, energy consumption, braking, curve driving ability, issues of vertical dynamics - safety and comfort when exposed to vibrations from road kinematic excitations.This course is designed also to provide the students with knowledge of the wide use of mechatronics to control vehicle dynamics - propulsion (automatic gearboxes, traction control systems), braking (ABS systems in hydraulic and pneumatic brake systems), steering and stability (ESP system) and vertical dynamics (controlled suspensions). For each of the systems, the processes subjected to control, the control methods and the practical technical solutions of mechatronic vehicle dynamics control systems are discussed. The method and problems of vehicle dynamics modelling and control are illustrated through the analysis of simulation models of the controlled systems and processes.

**Course-related learning outcomes**Knowledge
1. knows the basic mechatronic control systems of vehicle dynamics, their purpose, construction, possibilities and limitations [K\_W06, K\_W16, K\_W23]

2. knows the basic issues related to the physics of controlled processes and their models in relation to commonly used mechatronic control systems in vehicles [K\_W06, K\_W11]

Skills
1. can define the structure and construction of individual components of mechatronic vehicle dynamics control systems and indicate their possibilities and limitations [K\_U34]

2. has the skills allowing the use of computer science tools in conducting simulations and obtaining and integrating information in the design of mechatronic control systems for vehicle dynamics [K\_U08, K\_U28]

Social competences
1. is aware of the importance of mechatronic vehicle dynamics control systems for increasing the level of safety and is aware of the possibilities and limitations of control systems used in motor vehicles [K\_K07]

2. Is aware of the importance and understanding of non-technical aspects and effects of engineering activities, including its impact on the environment and the related responsibility for decisions [K\_K02]

**Methods for verifying learning outcomes and assessment criteria**Learning outcomes presented above are verified as follows:
Laboratory: assessment is based on reports on the exercises performed.Evaluation criteria: the correctness of the construction of models/test performed (50% of the assessment) and interpretation of model structure, vehicle dynamics and control idea desctiptions, conclusions (50% of the assessment).

Rating scale: below 50% - 2.0, from 50% - 3.0, from 60% - 3.5, from 70% - 4.0, from 80% - 4.5, from 90% - 5.0.

**Programme content**

LABORATORIES:

Laboratory 1 - introduction to the environment of simulation, longitudinal vehicle dynamics modelling

To acquaint students with the simulation environment, the way of entering data, presenting the results, building and modifying models (Matlab/ Simulink).

Laboratory 2 - longitudinal dynamics and cruise control system modelling

Analysis of the vehicle longitudinal velocity control process and the impact of its parameters on quality of automatic velocity control.

Laboratory 3 - modelling braking process, functioning of the ABS system

Discussion of the dynamics model of the braking process and the implemented method of control of this process. Analysis of the control process and the impact on it of modification of environmental parameters as well as the actuating system and the vehicle parameters.

Laboratory 4 - Gear shifting process in the automatic transmission

Discussion of the model of the dynamics of the car propulsion process, including the control of gear shifting. Discussion of the control model with the definition of the map of gear shifting and the effects achieved in the efficiency and the performance.

Laboratory 5 - Modeling of steady and transient curvilinear motion

Steady-state model with two degrees of freedom. The setting up of tire cornerring stiffness to obtain the desired handling characteristics. Determination of the maximum driving speed in a turn.

Laboratory 6 - Directional stability control

Discussion of the car lateral dynamics model with the implementation of the vehicle directional stability (yaw dynamics control, ESP) control. The study of the basic quantities defining the lateral dynamics of a car equipped with and wihout ESP system.

Laboratory 7 - Vertical dynamics control - semi-active suspensions

Vehicle vertical dynamics model (quarter car model). Kinematic and force excitations of suspensions. The role and evaluation criteria of suspensions in the area of vertical dynamics in terms of safety and driving comfort. Influence of damping and suspension stiffness. Dynamic characteristics of the suspensions. Suspension damping control - adaptive and semi-active. Sensors and actuators in controlled suspensions (including shock absorbers with adjustable damping - with bypass valves and magnetorheological).

**Teaching methods**

Laboratory exercises with the use of Matlab / Simulink or SciLab/Xcos systems.

**Bibliography**

Basic
1. Jazar, Reza N. : Vehicle Dynamics Theory and Application, Springer 2017

2. Rill G.: Rod Vehicle Dynamics - Fundamentals and Modeling, CRC Press, 2011

3. Abe M.: Vehicle Handling Dynamics - Theory and Application, Butterworth-Heinemann, 2015

4. Reif, K.: Automotive Mechatronics Automotive Networking, Driving Stability Systems, Electronics, Springer 2015

Additional
1. Ślaski G.: Studium projektowania zawieszeń samochodowych o zmiennym tłumieniu, Wydawnictwo Politechniki Poznańskiej, Rozprawy. Nr 481. ISSN 0551-6528, Poznań 2012

2. Bosch Automotive Handbook ?8th edition, Bentley Publishers, 2010

3. Rajamani R.: Vehicle Dynamics and Control, Springer 2012

4. Savaresi S., Poussot-Vassal Ch.,Spelta C. Sename O., Dugard L. :Semi-Active Suspension Control Design for Vehicles, Butterworth-Heinemann, 2010

**Breakdown of average student's workload**

|  | Hours | ECTS |
| --- | --- | --- |
| Total workload | 60 | 6,0 |
| Classes requiring direct contact with the teacher | 30 | 3,0 |
| Student's own work (literature studies, preparation for workshops, project preparation) [[1]](#footnote-1) | 30 | 3,0 |

1. delete or add other activities as appropriate [↑](#footnote-ref-1)