COURSE DESCRIPTION CARD - SYLLABUS

Course name
Vehicle dynamics modelling and simulation

Course

Field of study
Mechatronics
Area of study (specialization)
Mechatronic design of machines and vehicles
Level of study
Second-cycle studies
Form of study
full-time

Year/Semester
2/3
Profile of study
general academic
Course offered in
Polish
Requirements
elective

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
	30	
Tutorials	Projects/seminars	

Number of credit points

2

Lecturers

Responsible for the course/lecturer:
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Faculty of Mechanical Engineering

Piotrowo Street 3, 61-138 Poznan

Responsible for the course/lecturer:
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Faculty of Mechanical Engineering

Piotrowo Street 3, 61-138 Poznan

Prerequisites

Knowledge:The student has knowledge of 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 competencies: Understands the need and knows the possibilities of lifelong learning..

Course objective

The aim of the course is to provide knowledge on modeling and simulation of vehicle traffic as well as the ability to model and implement models in a computer simulation environment. The aim is also to practice the interpretation of simulation results in terms of the relationship between the excitations and the vehicles responses and their performance. The acquired knowledge will allow for the analysis and design or selection of vehicle components that provide the required functional characteristics in terms of dynamics. The scope of knowledge includes issues discussing the relationship between design parameters, and the dynamic properties of the vehicle such as acceleration ability, energy consumption, braking ability, curve driving ability, as well as vertical dynamics issues - safety and comfort when exposed to vibrations from kinematic excitations of roads.

Course-related learning outcomes

Knowledge

1. Knows the basic dependencies describing the mechanics of the car motion [K2_W04]

2. Has knowledge of the methods of modeling and simulating the longitudinal, lateral and vertical dynamic range of a vehicle [K2_W09]

Skills

1. Can describe the phenomena occurring while the car is moving and their physical dependencies [K2_U11]

2. Is able to build simulation models to predict the behavior of the vehicle, its performance or characteristics [K2_U07, K2_U15]

Social competences

1. Understands the areas of cooperation with the constructors of vehicle components [K2_K03]

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 [K2_K02]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Laboratory: assessment based on the results of the assessment of reports from the exercises performed.

Each of the exercises is assessed on the basis of the degree of implementation of the assigned tasks - passing the report when filling at least 50%. Rating scale - 50% - dst, 60% - dst +, 70% - db, 80% db +, 90% very good. The overall grade for the subject is an average grade from all submitted reports. It is imperative to obtain a positive grade from all reports.

Programme content

LABORATORIES:

Laboratory 1 - introduction of the environment of computer computing and simulation Matlab/Simulink lub SciLab/Xcos.

To acquaint students with the simulation environment, the way of entering data, presenting the results, building and modifying models.

Laboratory 2 - Modeling of motion resistance for a given driving cycle

Modeling the motion resistance of the vehicle and its traction characteristics with the use of a spreadsheet. Inference about vehicle performance from traction characteristics.

Laboratory 3 - Modeling of driving forces of the vehicle

Modeling the characteristics of the internal combustion engine and electric motors, modeling the drive train and wheel, modeling the influence of rotating masses

Laboratory 4 - Calculation of traction characteristics and its analysis

Preparing of traction and dynamic characteristics and acceleration diagram. Inference about vehicle performance (gradeability, acceleration ability).

Laboratory 5 - Modeling of power demand and energy consumption

Preparing the input data for the simulation - the driving cycle and changes in the road inclination. Modeling the demand for mechanical power and energy. Modeling the efficiency of the drive system and the drive source.

Laboratory 6 - Modeling of the braking process

Developing of the braking process model. Analysis of variables describing the process in terms of energy and safety.

Laboratory 7 - Modeling the load transfer during the braking process

Modeling of dynamic load transfer caused by longitudinal acceleration/deceleration and change of road inclination.

Laboratory 9 - Modeling of steady-state curvilinear motion

Discussion of the two degree of freedom model of lateral dynamics for research of steady state curvilinear motion. The setting of tire cornering stiffness to obtain the desired handling characteristics. Determination of the maximum driving speed in a curve.

Laboratory 10 - Modeling of curvilinear motion in a transient state

Overview of the two degree of freedom model for research of the transient curvilinear motion. Modeling of steer sinusoidal input.

Laboratory 8 - Modeling the load transfer for curvilinear motion

Development of a model of load transfer for curvilinear motion. Research on roll stiffnes and roll moment of inertia influence on vehicle roll dynamics.

Laboratory 11 - Driver modeling

Modeling of the lateral dynamics of the car taking into account the driver's model to control the curvilinear motion of the car (models with and without delay).

Laboratory 12 - Modeling of the vertical dynamics of suspensions

Overview of the vertical dynamics model of a car (quarter-car suspension) and examination of the influence of the setting of damping and stiffness on the dynamic characteristics and time responses of the suspension to selected types of kinematic excitations.

Laboratory 13 - Modeling the kinematic road excitations

Statistical description of road unevenness, spectral density of road unevenness of various quality classes, generation of the time course of kinematic excitation

Laboratory 14 - Modeling of the dynamic characteristics of the suspension

Discussion of the methods of generating the transfer function for the acceleration of the sprung mass, the suspension deflection and the dynamic loads of the wheels.

Laboratory 15 - Summarizing and final classes

Discussion of the results of laboratory reports. Evaluation of the subject.

Teaching methods

1. Laboratory - laboratory (experiment) method. Laboratory exercises with the use of Matlab / Simulink or SciLab/Xcos systems.

Bibliography

Basic

1. Prochowski L. .: Pojazdy samochodowe mechanika ruchu. Wydawnictwa Komunikacji i Łączności, Warszawa 2008.

2. Świder. P.: Teoria ruchu samochodów, cz. 1 , Wydawnictwo Politechniki Krakowskiej, 2012

3. Sczepaniak C.: Podstawy modelowania systemu człowiek-pojazd-otoczenie, Wydawnictwo Naukowe PWN, 1999.

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

5. Siłka W.: Teoria ruchu samochodu, WNT, Warszawa 2002

Additional

1. Pacejka Hans B.: Tire and Vehicle Dynamics, Butterworth-Heinemann, 2012

2. Smith C.: Tune to Win: The art and science of race car development and tuning, Osprey, 1987

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

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

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

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,0
Classes requiring direct contact with the teacher	30	1,0
Student's own work (literature studies, preparation for laboratory classes, reports preparation) [1]	20	1,0

[1] delete or add other activities as appropriate