COURSE DESCRIPTION CARD - SYLLABUS

Course name
Vehicle dynamics fundamentals and simulation [N1MiBM2>MiSRP]

Course

Field of study
Mechanical Engineering

Year/Semester
4/7

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
part-time

Requirements
elective

Number of hours

Lecture
8

Laboratory classes
8

Other (e.g. online)
0

Tutorials
0

Projects/seminars
0

Number of credit points

2,00

Coordinators

Lecturers

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 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 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 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.

Course-related learning outcomes

Knowledge:
1. Knows the basic dependencies describing the mechanics of the car movement [K_W03]
2. Has knowledge of the methods of modeling and simulating the longitudinal, lateral and vertical dynamic range of a vehicle [K_W05]

Skills:
1. Can describe the phenomena occurring while the car is moving and their physical dependencies [K_U01]
2. Is able to build simulation models to predict the behavior of the vehicle, its performance or characteristics [K_U07]

Social competences:
1. Is aware of the importance of correct vehicle dynamics design for increasing the level of safety and is aware of the possibilities and limitations of vehicle and driver [K_K07]
2. Understands the areas of cooperation with the constructors of vehicle components [K_K03]
3. 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:

Lectures: Written test, which is based on answers related to the selection of given answers and open questions. Credits will be given after achieving at least 50% of points. Answers are scores from 0 to 1 point.
Laboratories: assessment is based on the results of the current control of preparation for classes and reports on the exercises performed.

Programme content

LECTURES:
Lecture 1 - Vehicle motion resistance, traction characteristics, energy consumption
Overview of the place of the vehicle in the driver-vehicle-environment system. Types of excitations acting on the vehicle - force and kinematic. Overview of the sources of resistance to vehicle motion (rolling, air, elevation, inertia). Discussion of the characteristics of vehicle propulsion sources and their transformation into traction characteristics. The use of traction characteristics to infer about the performance of the vehicle. Vehicle power balance. Demand for mechanical energy. Driving cycles. Efficiency of the drive system. Energy recuperation.
Lecture 2 - Tire properties and vehicle braking, weight transfer caused by longitudinal dynamics
The importance of the tire for producing longitudinal and lateral forces. Vehicle braking process - forces, decelerations, speed and distance traveled as a function of time and speed changes as a function of the distance traveled. Limitations and optimization of the braking process, the impact of the driver's reaction time. Energetic aspects of braking. Weight transfer caused by longitudinal forces - acceleration, braking Acceleration and braking limitations influence.
Lecture 3 - Vehicle curvilinear motion, weight transfer caused by lateral dynamics
Variables describing the curvilinear motion of the vehicle. Balance of forces in a curve (turn). Pneumatic tire side slip and large sideslip over friction limits. Handling characteristics - understeer and oversteer. Directional and roll stability of the vehicle in steady motion and in transient states. Weight transfer caused by lateral forces from curvilinear motion. Influence on vehicle stability.
Lecture 4 - Vehicle vibrations - the sources and impact on the safety and comfort of driving
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 time responses.
LABORATORIES:
Laboratory 1 - Modeling of motion resistances and calculation of vehicle traction characteristics
Modeling the motion resistance forces of the vehicle and its traction characteristics with the use of a spreadsheet. Inference about vehicle performance from traction characteristics. Modeling the demand for mechanical power and energy. Modeling the efficiency of the drive system and the power generators.
Laboratory 2 - Modeling of the braking process
Developing of the braking process model. Research on the course of variables describing the process in

terms of energy and safety. Construction of models of weight transfer on vehicle axles and wheels.
Laboratory 3 - Modeling of steady and transient curvilinear motion
Steady-state model with two degrees of freedom. The setting up of tire cornering stiffness to obtain the desired handling characteristics. Determination of the maximum driving speed in a turn.
Laboratory 4 - Modeling of the suspension dynamics
Discussion of the vertical dynamics model of a car (quarter-car suspension) and research on the influence of the selection of damping and stiffness on the dynamic characteristics and time responses of the suspension to selected types of kinematic excitations.

Course topics

none

Teaching methods

1. Lecture with a multimedia presentation - a combination of an information and problem lecture;
2. 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. Jazar, Reza N. : Vehicle Dynamics Theory and Application, Springer 2017
3. 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
6. Milliken W.F., Milliken D.L.: Race Car Vehicle Dynamics, SAE, 1993.

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	16	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	34	1,00