COURSE DESCRIPTION CARD - SYLLABUS

Course name
Fundamentals of vehicle design and dynamics [S1Elmob1>PBiTRP]

Course

Field of study
Electromobility

Year/Semester
2/3

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other (e.g. online)
0

Tutorials
15

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

Basic knowledge of mechanics, in particular the kinematics and dynamics of discrete systems. Knowledge of the basic principles of formulating dynamics. Spreadsheet usage practice. The ability to identify problems and solve dilemmas in the computational process. Independence. The student has a basic knowledge of machine science, mechanics, the basics of machine design and the laws of physics. The student is able to integrate the obtained information, interpret it, draw conclusions, read diagrams and technical drawings.

Course objective

Providing students with information on the basic relations between the design parameters of vehicles, road conditions and the requirements of motion dynamics, while maintaining safety and driving comfort. Provide students with basic information on the design and operation of car chassis and body systems as well as general requirements for motor vehicles.

Course-related learning outcomes

Knowledge:
1. Knows the basic dynamics relationships describing the motion of a car. 2. Has knowledge of how to

solve problems in the field of longitudinal, lateral and vertical dynamics of the vehicle. 3. Knows the algorithms leading to the correct determination of the vehicle"s behavior on the road. 4. Knows the procedures of determining the basic characteristics of the car. 5. The student knows the tasks, structure and properties of various types of basic vehicle systems.

Skills:
1. Is able to define the phenomena occurring during the car motion in the form of mathematical relations. 2. He can solve the problems of car dynamics. 3. Knows how to determine the relationship between the design and traction parameters of the vehicle and its motion properties. 4. Is able to select kinematic and dynamic solutions to ensure adequate comfort and safety of driving. 5. The student can describe the tasks, principles of operation, design and functional variations, properties and the scope of applications of various solutions of mechanisms and assemblies of the main vehicle systems.

Social competences:
1. Can independently define priorities, problems and solutions in the field of vehicle dynamics. 2. Can cooperate with people involved in the design of vehicle construction solutions. 3. Understands the requirements for driving comfort and safety.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Written exam on the lecture material, passing the exercises on the basis of a test.

Programme content

Fundamentals of Vehicle Dynamics: The course covers vehicle dynamics in longitudinal, lateral, and vertical aspects. It discusses propulsion aspects, performance, traction characteristics, and energy demands of vehicles. The braking process includes power, energy, and differences between emergency and operational braking. Lateral dynamics focus on steering theory, vehicle control, tire influence, and stability. Vertical dynamics analyze suspension evaluation and the impact of stiffness and damping on comfort and safety.

Fundamentals of Vehicle Construction: The course covers technical characteristics of cars, legal requirements, and the division into functional subsystems (body, chassis, drive systems, safety systems). It discusses ergonomic, mechanical, aesthetic aspects, safety of bodies and drive systems, as well as the structure and functions of steering, braking, and suspension systems.

Scope of Exercises: Exercises include modeling of motion resistances, calculations of traction characteristics, performance, and braking processes, energy demand models, as well as calculations of steerability, lateral stability, and stiffness and damping parameters of the vehicle.

Course topics

Fundamentals of vehicle dynamics theory:
1. Division into basic areas of dynamics - longitudinal, lateral and vertical. Longitudinal dynamics - car propulsion process - performance (acceleration ability, maximum speed, hill climbing ability, towing ability), car traction and dynamic characteristics. Energy aspects of a car motion - propulsion and nonpropulsion energy demand, power of motion resistances, driving cycles, characteristics of internal combustion engines and electric motors, hybrid powertrain systems (purposefulness of use from the perspective of energy demand, methods of accumulating kinetic energy of the car).
2. The process of car braking - time histories and energy aspects - braking power and energy, emergency braking versus service braking, regenerative braking.
3. Lateral car dynamics - the theory of car turning for low speeds, the possibility of automating the parking process. Forces affecting the car while driving in a curve at higher speeds, controlling the car"s lateral dynamics - generating lateral forces, the car"s response - yaw rate, car drift angle, the influence of tires on the car"s lateral dynamics - drift angles, steering characteristics, lateral dynamics in transient states (sudden lane change), vehicle motion stability, importance of the moment of inertia around the vertical axis - the value and distribution of mass, car tilting stability.
4.Vertical dynamics of the car - criteria and indexes of the suspension assessment - comfort and safety

and suspension design limitations, dynamics of the two degre of freedom system - characteristics of the body vibration amplification, tire loads, suspension deflections, resonances, the influence of the choice of stiffness and damping, influence of the variability of the sprung mass .
Basics of vehicle structure design:
5 Basic technical characteristics of cars, legal requirements and restrictions for the construction of motor vehicles, division of the car into functional subsystems (body, chassis: suspension, steering system, braking system, transmission, types of powertrain systems, active and passive safety systems, car interior fittings, ventilation, heating and air conditioning systems).
6.Bodies and powertrain systems - ergonomic, mechanical, aesthetic and safety aspects - the ability to absorb energy by the crumple zone and the strength of the passenger compartment. Aspects of the relationship between strength (bending and torsional stiffness) and body weight. Basic solutions of the powertrain systems of internal combustion engines and electric motor cars. Gear boxes, clutches and shafts.
7. Chassis systems (steering, braking and suspension) - structure of the steering system, steering and steering mechanism, power steering systems, structure of the brake system, braking mechanisms and brake actuation mechanisms, control systems in braking systems (ABS, EBS), suspension functions - functions of transferring vertical forces (vertical vibrations) as well as longitudinal and transverse - leading elements of suspensions, types of kinematic systems of suspensions (McPherson, transverse, longitudinal and oblique wishbones, torsion beam), elastic elements (springs, springs, air bellows, hydropneumatic suspensions) and damping (types and construction of shock absorbers).
EXERCISE SCOPE
1. Models and estimation of resistance to motion
2. Calculations of traction characteristics for internal combustion and electric powertrain systems
3. Performance calculations
4. Calculation of the braking process - performance and energy aspects
5. Calculation of energy demand for propulsion purposes - "backward facing" models
6. Calculations of steering characteristics and lateral stability.
7. Calculations of the required stiffness and damping parameters for various load conditions of the vehicle.

Teaching methods

1. Lecture: multimedia presentation. 2. Exercises: formulation and solution of given problems in the dynamics of the car.

Bibliography

Basic
1. Prochowski L. .: Pojazdy samochodowe mechanika ruchu. Wydawnictwa Komunikacji i Łączności, Warszawa 2008.
4. Jackowski J., Łęgiewicz J., Wieczorek M.: Samochody osobowe i pochodne. WKŁ, W-wa, 2011
5. Prochowski L., Żuchowski A.: Samochody ciężarowe i autobusy. WKŁ, W-wa, 2004
6. Gabryelewicz M.: Podwozia i nadwozia pojazdów samochodowych cz. 2 Układ hamulcowy i kierowniczy, zawieszenie oraz nadwozie. WKŁ, W-wa, 2018
7. Zieliński A.: Konstrukcja nadwozi samochodów osobowych I pochodnych, WKiŁ, 2008
Additional
1. Wong J.Y.: Theory of Ground Vehicles, J.Whiley&Sons, 2001
2. Heising B., Ersoy M.: Chassis Handbook. Vieweg + Teubner Verlag, Wiesbaden, 2011
3. Breuer B., Bill K.: Brake Technology Handbook. SAE International, Warrendale, 2008
4. Harrer M., Pfeffer P.: Steering Handbook. Springer, 2017
5. Morello L., Rossini L. R., Pia G., Tonoli A.: The Automotive Body, Volume I: Components Design, Springer 2011
6. Morello L., Rossini L. R., Pia G., Tonoli A.: The Automotive Body, Volume II: System Design, Springer 2011
7. Ślaski G.: Studium projektowania zawieszeń samochodowych o zmiennym tłumieniu, [A study of designing a vehicle suspension with variable damping], Wydawnictwo Politechniki Poznańskiej, Rozprawy. Nr 481. ISSN 0551-6528, Poznań 2012

Breakdown of average student's workload

	Hours	ECTS
Total workload	58	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	28	1,00