COURSE DESCRIPTION CARD - SYLLABUS

Course name

Computer simulations in studies of machines and vehicles

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

Tutorials

Laboratory classes
30

Projects/seminars

Other (e.g. online)

Number of credit points

2

Lecturers

Responsible for the course/lecturer:
PhD Eng. Krzysztof Wałęsa
email: krzysztof.walesa@put.poznan.pl
tel. +48 61 665 2318
Faculty of Mechanical Engineering
Piotrowo 3 Street, 61-138 Poznań

Responsible for the course/lecturer:
PhD Eng. Hubert Pikosz
email: hubert.pikosz@put.poznan.pl
tel. +48 61 665 2318
Faculty of Mechanical Engineering
Piotrowo 3 Street, 61-138 Poznań

Prerequisites

Knowledge: information in the field of: principles of the modeling in 3D CAD systems, strength of the materials, technical mechanics, basics of the thermodynamics and fluid mechanics, basics of finite element method.

Skills: preparing of the 3D CAD models of parts of the machines and vehicles, shaping of the constructional features of machine parts, independent formulation of the technical problem based on the analysis of physical phenomena, self-education using modern didactic tools.

Social competences: understanding the need of expansion of the knowledge and skills, readiness to take a discussion on the problem of solved.

Course objective

The main objective of the course is to acquire and develop the skills of conducting computer simulations of physical phenomena occurring in mechatronic devices and vehicles, in particular during their interaction with the environment, as well as proper interpretation of the results obtained. Additional objectives concern the development of the skills of selecting a suitable engineering tool for the type and complexity of the task and acquisition or developing the skills of using ANSYS Mechanical/CFD and Siemens NX and MSC ADAMS software packages.

Course-related learning outcomes

Knowledge

1. The student has extended knowledge of the mechatronics, of knowledge of analysis and design of complex mechatronic systems, theories and techniques of systems and the use of modeling and simulation in mechatronic design [K2_W09].

2. The student has knowledge of a computer design analysis including advanced operations in the CAD environment regarding 3D visualization and analysis of the cooperation between mechanical components [K2_W15].

3. The student has knowledge necessary to understand social, economic, legal and non-technical conditions of engineering activities and to take into account them in engineering practice [K2_W18].

4. The student has knowledge of the structure of the chassis subsystem of motor vehicles and the methods and scope of their kinematic and dynamic analyzes.

Skills

1. The student is able to determine the directions of further learning and carry out the self-employment process [K2_U05].

2. The student can design complex devices and mechatronic systems using modeling and simulations. He can plan and carry out experiments, including measurements and computer simulations, interpret the results obtained and draw conclusions [K2_U114].

3. The student can perform a visualization of a mechanical element in a 3D environment and analysing the cooperation of elements shown in the figure [K2_U19].

4. The student is able to use tools for the analysis of multibody systems in order to analyze the kinematics and dynamics of the mechanisms of vehicle chassis.

Social competences

1. The student understands the need for lifelong learning; He can inspire and organize the learning process of other people [K2_K01].

2. The student shall be aware of the validity and understanding of the non-technical aspects and effects of engineering activities, including its impact on the environment and the related responsibility for decisions taken [K2_K02].

3. Student can determine priorities for the implementation of the specified by themselves or other tasks [K2_K04].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The final grade of the laboratory is averaged from particular grades granted for individual performing tasks during the classes, according to standard assesment scale. Solutions of the tasks will be evaluated on the basis of synthetic reports with paying attention to interpretation of the obtained results.

Programme content

Classes 1, 2 and 3: Introduction to the Siemens NX and ANSYS Mechanical/CFD

At classes, students will get acquainted with the Siemens NX software package and its possibilities by preparing a 3D model and execution of the strength analysis of key elements, for a simple multiple-element mechanism. Then students will get acquainted with the ASYS Mechanical/CFD software package and its possibilities by importing a model prepared on earlier classes and execution of strength analysis of key elements. Students will have the opportunity to compare the results obtained from both computing systems.

Classes 4 and 5: Dynamic simulations of machines

At classes, students will get acquainted with the principles of conducting the simulation of the dynamics of mechanical systems, in particular issues related to: vibrations of mechanical systems, inertia and balancing and determining power consumption taking into account the dynamics of the system.

Classes 6, 7 and 8: Simulation of the fluid systems and coupled fluid-mechanical analysis

At classes, students will get acquainted with the methods of simulating fluid systems, in particular hydrodynamic and aerodynamic. Based on a few examples, students acquire knowledge about obtaining the distribution of velocities during flow and pressure around the flowed system, as well as information on how to determine the drag coefficient. In the second part of the classes, students get acquainted with the basic principles of building a model for coupled fluid-mechanical analyses of type FSI (Fluid-Structure Interaction), in the aspect of the impact of a mechanical object on the behaviour of the flowing fluid (liquid or gas) and the influence of a liquid domain on the stress state of the flowing condition object.

Classes 9 and 10: Thermal and thermo-mechanical analyses

At classes, students on the basis of several examples will get acquainted with the principles of exercising thermal and thermomechanical simulations related to cooling/heating issues of elements subject to, for example, heat treatment, cooling/heating of mechatronic units in which heat is generated, as well as with the issue of heat generation as a result friction and influence of thermal stresses on the condition of straining structural elements.

Class 11: Design of a vehicle suspension subsystem

The aim of the laboratory is to get acquainted with the ADAMS Car interface and the principles of building models of multibody suspension mechanisms of automotive vehicles (e.g. McPherson, double-wishbones, multi-link suspensions), together with defining the parameters necessary for dynamic analyzes (characteristics of stiffness and damping, masses, moments of inertia).

Class 12: Analysis of the kinematics and dynamics of the vehicle suspension system

The aim of the laboratory is to conduct simulation tests of kinematic characteristics (changes of camber, toe-in, camber and caster angle) and dynamic characteristics (frequency responses functions due to kinematic excitation for body acceleration, suspension deflection and wheel dynamic loads).

Class 13: Design of a steering system model and its integration with the vehicle suspension system

The aim of the laboratory is to build a multibody model of various variants of the steering system and its kinematic and dynamic analysis. The roll steer and bump steer will be investigated.

Class 14: Assembly a full car model in a simulation environment

The aim of the laboratory is to build a full car model by assembling models of suspension, steering, driveline, braking and body systems. Tire model implementation.

Class 15: Analysis of the handling characteristics and motion stability of a full car model

The aim of the laboratory is to make a simulation tests for steady state circle driving, single and double lane change, and interpretation of the obtained results.

Teaching methods

Laboratory method (experiment): students will work individually on tasks - examples assigned by the teacher. Teacher, in the introduction to the classes will discuss chosen cases (case study).

Bibliography

Basic

1. Mazur Damian, Rudy Marek, Modelowanie w systemie NX CAD, Oficyna Wydawnicza Politechniki Rzeszowskiej, 2016.

2. Mrzygłód Mirosław, Podstawy analizy wytrzymałościowej konstrukcji w programie ANSYS/Mechanical APDL, Wydawnictwo Politechniki Krakowskiej, 2014.

3. Krzesiński Grzegorz, Zagrajek Tomasz, Marek Piotr, Borkowski Paweł, Metoda elementów skończonych w mechanice materiałów i konstrukcji: rozwiązywanie wybranych zagadnień za pomocą systemu ANSYS, Oficyna Wydawnicza Politechniki Warszawskiej, 2015.

4. Skrzat Andrzej, Modelowanie liniowych i nieliniowych problemów mechaniki ciała stałego i przepływów ciepła w programie ANSYS Workbench, Oficyna Wydawnicza Politechniki Rzeszowskiej, 2019.

5. Bielski Jan, Inżynierskie zastosowania systemu MES, Wydawnictwo Politechniki Krakowskiej, 2013.

6. Rakowski Gustaw, Kacprzyk Zbigniew, Metoda elementów skończonych w mechanice konstrukcji, Oficyna Wydawnicza Politechniki Warszawskiej, 2016.

7. Bąk Roman, Burczyński Tadeusz, Wytrzymałość materiałów z elementami ujęcia komputerowego Wydawnictwo Naukowo-Techniczne, 2017.

8. Blundell M., Harty D.: Multibody Systems Approach to Vehicle Dynamics, Elsevier Books, 2014.

9. Lozia Z., Guzek. M., Przegląd metod badań stateczności i kierowalności pojazdów samochodowych. Zeszyty Instytutu Pojazdów Politechniki Warszawskiej 2(14)/95.

Additional

1. Mazur Damian, Gołębiowski Marek, Rudy Marek, Modelowanie i analiza układów elektromechanicznych metodą elementów skończonych, Oficyna Wydawnicza Politechniki Rzeszowskiej, 2016.

2. Pawłucki Mateusz, Kryś Maciej, CFD dla inżynierów: praktyczne ćwiczenia na przykładzie systemu ANSYS Fluent, Wydawnictwo Helion, 2020.

3. Zienkiewicz Olgierd Cecil, Metoda elementów skończonych, Wydawnictwo Arkady, 1972.

4. Wałęsa Krzysztof, Malujda Ireneusz, Talaśka Krzysztof, Wilczyński Dominik, Process analysis of the hot plate welding of drive belts, Acta Mechanica et Automatica, 14(2), 84-90.

5. Wałęsa Krzysztof, Malujda Ireneusz, Górecki Jan, Wilczyński Dominik, The temperature distribution during heating in hot plate welding process, MATEC Web of Conferences, 254, 02033.

6. ISO 4138:2012: Passenger cars — Steady-state circular driving behaviour — Open-loop test methods.

7. ISO 3888-1:2018: Passenger cars — Test track for a severe lane-change manoeuvre — Part 1: Double lane-change.

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, report preparing) [1]	20	1,0

[1] delete or add other activities as appropriate