COURSE DESCRIPTION CARD - SYLLABUS

Course name

Advanced methods of machine design

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

1/2

Profile of study

general academic

Course offered in

Polish

Requirements

elective

Number of hours

Lecture

0

Tutorials

0

Laboratory classes

15

Projects/seminars

15

Other (e.g. online)

0

Number of credit points

2

Lecturers

Responsible for the course/lecturer:

PhD Eng. Dominik Wojtkowiak

email: dominik.wojtkowiak@put.poznan.pl

tel. 61 224 4516

Faculty of Mechanical Engineering

Piotrowo Street 3, 61-138 Poznań

Responsible for the course/lecturer:

Prof. Krzysztof Talaśka

email: krzysztof.talaska@put.poznan.pl

tel. 61 665 2244

Faculty of Mechanical Engineering

Piotrowo Street 3, 61-138 Poznań

Prerequisites

Knowledge: Basic knowledge of mathematics, materials science, mechanics, the basics of machine design, theory of machines and mechanisms as well as the strength of materials acquired during the 1st and 2nd degree studies.

Skills: Basics of vector and matrix calculus, the ability to solve ordinary differential equations, the ability to solve simple problems in the mechanics and strength of materials, the ability to carry out engineering calculations and selection of elements, the ability to design machines and devices, the ability to create technical documentation, knowledge of CAD programs.

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.

Course objective

The aim of the course is to familiarize students with the mathematical apparatus necessary in the processes of modeling materials and machines (mechanisms), with the basics of physical and mathematical modeling of construction materials, mechanisms and machines, as well as with methods of optimization and computer simulation of both structures and technological processes, with an emphasis on practical using these skills in the design and construction of machines and devices.

Course-related learning outcomes

Knowledge

Has in-depth knowledge of engineering applications of mathematics, in particular solving differential equations, discrete equations, determining the eigenvalues of matrices, eigenvectors and modal matrices, and solving basic nonlinear ordinary and partial differential equations. This knowledge enables mathematical modeling of the properties of the mechanical, electrical and control parts of mechatronic devices and the description of digital discrete, impulse and nonlinear systems as well as discrete algorithms. [K2_W01]

Has an extended knowledge of the strength of materials related to the safety and reliability of mechanical structures, calculation of composite elements, frames and curved bars as well as thin-walled tanks and thick-walled vessels. Has knowledge of the basics of optimal structure design. [K2_W03]

Has knowledge of computer structure analysis including advanced operations in the CAD environment, regarding 3D visualization and analysis of the cooperation of mechanical elements. [K2_W15]

Has an extended knowledge of mechatronics, knowledge of the analysis and design of complex mechatronic systems, systems theory and technology, and the application of modeling and simulation in mechatronic design. [K2_W09]

Skills

He can visualize a mechanical element in a 3D environment and analyze the cooperation of elements shown in the drawing. [K2_U19]

He can perform strength calculations allowing to determine the safety and reliability of selected mechanical structures. Is able to determine the strength of basic composite elements, frames and curved bars as well as thin-walled tanks and thick-walled vessels. [K2_U09]

Can design complex mechatronic devices and systems, using modeling and simulations. He can plan and carry out experiments, including measurements and computer simulations, interpret the obtained results and draw conclusions. [K2_U14]

He can use computer systems to design and operate mechatronic devices. Can implement control systems in the real-time operating system. He can use the basic methods of image processing and analysis. He can prepare software documentation. [K2_U15]

Social competences

Understands the need for lifelong learning; can inspire and organize the learning process of other people. [K2_K01]

Can set priorities for the implementation of a task set by oneself or others. [K2_K04]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Laboratory: Final assignement in the form of verification of practical skills of solving design tasks with the use of modeling. Assignement takes place during the last laboratory class and lasts 90 minutes. Ongoing verification of acquired skills during laboratory exercises.

Evaluation criteria: the correctness of the construction of the model of the designed structure is assessed (75% of the assessment) and its implementation in the selected computer program (25% 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.

Projects: Evaluation based on an individual project related to the topic of the thesis.

Evaluation criteria: the correctness of the construction of models of the designed structure is assessed (50% of the assessment) and their use in the design process of the selected structure (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 software used for modeling during laboratory classes

Laboratory 2 - Modeling of the kinematics of mechanical systems in design

Denavit-Hartenberg notation - problem of simple and inverse kinematics. Modeling in designing the structure of mechanical systems. Machine movement modeling. Designating the work zone.

Laboratory 3 - Modeling of machine dynamics in design

Dynamics of mechanical systems - type II Lagrange equations. Determination of dynamic substitute parameters. Modeling in the design of damping and drive systems.

Laboratory 4 - Modeling of the stress state in structural elements in design

Stress and strain tensors. Modeling of the stress state in structural elements in terms of designing machine working systems.

Laboratory 5 - Modeling of material properties in design

Derivation of the characteristics of rheological models of materials. Modeling of material properties in computer simulations.

Laboratory 6 - Modeling of electromechanical systems in design

Closed loop method - analogies between mechanical and electrical systems. Modeling the dynamics of an electromagnet and a DC motor. Modeling in the design of mechatronic devices.

Laboratory 7 - Modeling of fluid systems in design

Analogies between mechanical and fluid systems. Modeling of hydrostatic and hydrodynamic systems - actuators, valves, servomechanisms. Simulation and design of systems with hydraulic drive.

Laboratory 8 - Final assignement

Completion of the laboratory in the form of verification of practical skills of solving design tasks with the use of modeling.

Projects:

Project 1 - Overview of sample projects.

Project 2 - Development of the topic and scope of the project based on the topic of the thesis.

Project 3 - Overview of practical examples of applying simple and inverse kinematics in design.

Project 4 - Overview of practical examples of applying simple and inverse dynamics in design.

Project 5 - Overview of practical examples of the use of stress state modeling in structural elements in the design of working systems.

Project 6 - Overview of practical examples of the application of electromechanical and fluid systems modeling in the design of mechatronic devices.

Project 7 - Consultation classes.

Project 8 - Completion of the project.

Teaching methods

Tutorials: Blackboard exercises with a multimedia presentation, with the use of the case study method - analysis of a solution to real design problems.

Projects: Workshop methods of practical design classes. Project methods.

Bibliography

Basic

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2. Czemplik A., Modele dynamiki układów fizycznych dla inżynierów.

3. Heimann B., Gerth W., Popp K., Mechatronika. Komponenty, metody, przykłady. PWN, Warszawa 2001.

4. Ambrosio J.A.C., Eberhard P.: Advanced Design of Mechanical Systems: From Analysis to Optimization, SpringerWienNewYork 2009.

Additional

1. Jezierski E., Dynamika robotów, WNT, Warszawa 2006.

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3. Z. Parszewski; Drgania i dynamika maszyn, WNT, Warszawa 1982.

4. W. Tarnowski; Modelowanie systemów, Wyd. Politechniki Koszalińskiej, Koszalin 2004.

5. Bąk R., Burczyński T., Wytrzymałość materiałów z elementami ujęcia komputerowego, wyd. WNT, Warszawa 2013.

6. R. H. Cannon jr.; Dynamika układów fizycznych, WNT, Warszawa 1973.

7. Spong M., Vidyasagar M., Dynamika i sterowanie robotów, WNT, Warszawa 1997.

8. Derski W., Ziemba S., Analiza modeli reologicznych, Wyd. PWN, Warszawa 1968.

9. Wojtkowiak D., Talaśka K., Wilczyński D. i inni: Determining the Power Consumption of the Automatic Device for Belt Perforation Based on the Dynamic Model, Energies 14:1, 317, 1-15, 2021.

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, preparation for tests, project preparation) [1]	20	1,0

[1] delete or add other activities as appropriate