COURSE DESCRIPTION CARD - SYLLABUS

Course name
Modeling of mechanical systems

Course

Field of study	Year/Semester
Construction and Exploitation of Means of Transport	1/2
Area of study (specialization)	Profile of study
Internal Combustion Engines	general academic
Level of study	Course offered in
Second-cycle studies	polish
Form of study	Requirements
part-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
9	0	0
Tutorials	Projects/seminars	
18	0	

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
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Responsible for the course/lecturer:
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Prerequisites

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

Skills: Basics of vector and matrix calculus, ability to solve ordinary differential equations, ability to solve simple problems in mechanics and strength of materials, ability to conduct engineering calculations and selection of elements, ability to design machines and devices, 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, gaining 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 the 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

1. Has a general knowledge of the principles and methods of constructing working machines, in particular the methods of functional and strength calculations, mathematical optimization of mechanical structures and modeling of machine structures in 3D systems

2. Knows contemporary engineering methods of computer graphics and theoretical foundations of engineering calculations using the finite element method

3. Has extended knowledge in the field of computer science, concerning computer programming and engineering calculation programs in the field of computer simulation of physical systems

4. Has basic knowledge of the mechanics of solids and discrete systems with many degrees of freedom, mathematical modeling of physical and mechanical systems based on d'Alembert's principle and Lagrange's equations, mathematical description of materials using constitutive equations.

Skills

1. Can use a popular numerical system to program a simple system simulation task with a small number of degrees of freedom

2. Can perform a medium complex design of a working machine or its assembly with the use of modern CAD tools, including tools for spatial modeling of machines and calculations using the finite element method

3. Is able to use the methods of modeling supporting designing to construct effective machines and devices.

Social competences

1. Is ready to critically assess the knowledge and content received

2. Is ready to recognize the importance of knowledge in solving cognitive and practical problems and to consult experts in the event of difficulties in solving the problem on its own

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Written test during the last lecture, checking the knowledge of the theory and the ability to use it in practice. Completion of exercises on the basis of individual final work in the form of a machine or device design with the use of modeling elements in the construction process, handed over at the latest during the last class. Checking the understanding of the material on an ongoing basis by solving problems on the blackboard during classes.

Programme content

Lecture: Notes on modeling - goal, entities of modeling. Modeling process - stages of modeling, diagram. Physical modeling - simplifying assumptions, physical quantities, examples of physical models. Mathematical modeling - the basics of modeling, tensor quantities, coordinate systems, rules for formulating constitutive relations, formulating and solving equations of motion in mechanical systems. Mathematical models of construction materials - single-parameter models, complex models, selected non-classical models. One- and two-parameter mechanical systems - equations of motion, undamped and damped vibrations. Mathematical models of selected processes - electromechanical systems and hydrodynamic systems. Analogies between physical environments. Mathematical modeling of machines and devices - kinematics and simple and inverse dynamics (Denavit-Hartenberg notation), modeling of the stress state in structural elements, determination of dynamic equivalent parameters. Construction of simulation models, finite element method (FEM). Design optimization.

Tutorials: Derivation of the characteristics of rheological models of materials. Stress and strain tensors. Modeling of the state of stress in structural elements. Dynamics of mechanical systems - type II Lagrange equations. Determination of dynamic replacement parameters. Denavit-Hartenberg notation - task of simple and inverse kinematics. Construction of a FEM simulation model. Structure optimization. Ring method - analogies between mechanical and electrical systems. Modeling the dynamics of an electromagnet and a DC motor.

Teaching methods

Informative lecture with a multimedia presentation, using the case study method - analysis of solutions to real construction problems.

Classes conducted in the form of auditorium exercises - practical use of the skills provided during the lecture, using the demonstration method (tasks at the blackboard solved by the teacher with the necessary commentary) or instruction (tasks at the blackboard solved by students with the help of the teacher). A demonstration with an overview of the use of computer programs. Consultations on the results of students' own work as part of their final projects.

Bibliography

Basic

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

2. Ostwald M.: Podstawy optymalizacji konstrukcji. Wyd. Politechniki. Poznańskiej 2005.

3. Wrotny L.T., Zadania z kinematyki i dynamiki maszyn technologicznych i robotów przemysłowych, Wyd. PW, Warszawa 1998.

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

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

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

7. Ostrowska-Maciejewska; Podstawy mechaniki ośrodków ciągłych, PWN, Warszawa 1982

8. Szturmowski B., Inżynierskie zastosowanie MES w problemach mechaniki ciała stałego na przykładzie programu ABAQUS, Wyd. Akademii Marynarki Wojennej, 2013

9. Skrzat A., Modelowanie liniowych i nieliniowych problemów mechaniki ciała stałego i przepływów ciepła w programie ANSYS Workbench/Abaqus, Wyd. Politechniki Rzeszowskiej, 2014

Additional

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

2. R. Scanlan, R. Rosenbaum; Drgania i flatter samolotów, PWN, Warszawa 1964

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

4. W. Flügge; Tensor analysis and continuum mechanics, Springer-Verlag, Berlin 1972

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.

Breakdown of average student's workload

	Hours	ECTS
Total workload	70	3,0
Classes requiring direct contact with the teacher	45	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	25	1,0

[1] delete or add other activities as appropriate