COURSE DESCRIPTION CARD - SYLLABUS

Course name
Methodology of conducting experimental research [S2MiBM2>MPBD]

Course

Field of study
Mechanical Engineering

Year/Semester
1/1

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
15

Projects/seminars
0

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

Knowledge: Basic knowledge of mathematics, materials science, mechanics, basics of machine design, theory of machines and mechanisms, strength of materials, automation and robotics acquired during first-cycle studies. Skills: Ability to independently formulate a technical problem, develop a construction record in accordance with the principles of technical drawing, calculate the strength of machine elements, shape the design features of machine components, formulate control algorithms, identify parameters of technological processes. Social competences: Understanding the need to expand one's competences, readiness to cooperate within a team.

Course objective

The aim of the course is to familiarize the student with the methodology of conducting experimental research, developing research methodology, conducting research, developing research results and drawing conclusions.

Course-related learning outcomes

Knowledge:
Has extended and deepened knowledge of mathematics, including solving discrete equations classically

and using the Z transformation, determining eigenvalues of matrices, eigenvectors and modal matrix, solving nonlinear ordinary and partial differential equations to describe complex mechanical problems. [K2_W01]
Has extended and deepened knowledge of the strength of materials, understands the basic models and computational methods used in construction. Has structured, theoretically based general knowledge that allows you to calculate: force systems, balance of plane and spatial systems; determine support values; analyze: statics of beams, columns, frames and trusses; describe: elements of the theory of stress and strain, linear elastic systems; calculate allowable stresses; describe: stress hypotheses, stress of machine elements; correlate material selection criteria with models of technical mechanics and material strength; can link technical mechanics and strength of materials with computer techniques. [K2_W04]
Has knowledge in the field of modeling supporting machine design, including simplifying assumptions used in modeling, creating a physical model of a mechanical system, formulating model equations and methods of solving them, identifying system parameters, model verification methods, advanced methods of modeling multi-race systems, formulating and solving dynamics problems, shaping machine elements based on strength criteria, non-linear issues, optimization methods, integrated systems (CAE - Computer Aided Engineering), used to model and calculate complex mechanical systems using numerical methods; knows the basic concepts and practical applications of modern optimal design methods, optimization procedures and their practical engineering applications. [K2_W07]
Has in-depth and extended knowledge of modern engineering materials, including the basics of shaping the structure and properties of engineering materials, modern engineering materials with specific properties and their use as elements of machines and tools. Knows the principles of selecting engineering materials, computer-aided material design and the selection of materials used for material design. [K2_W09]

Skills:
Is able to prepare a scientific study in Polish and a short scientific report in a foreign language considered basic for the fields of science and scientific disciplines relevant to mechanics and machine construction, presenting the results of own scientific research; can prepare and present an oral presentation in Polish and foreign languages on detailed issues in the field of mechanics and machine construction. [K2_U03]
Is able to interpret natural and technical phenomena based on knowledge of the theory of elasticity and plasticity; can perform simple calculations related to elastic or plastic stresses, write a simple computer program to perform more complex calculations of stresses and strains in the elastic and plastic range. [K2_U11]
is able to design and select engineering materials, is able to develop an opinion on the selection of material and product manufacturing technology, is able, after discussion with designers, to indicate how to correct the existing material solution and make a binding decision, assess the properties and optimal use of materials, select the right material for specific machine parts, determine the cause of damage to machine parts, assess the costs of materials used. [K2_U12]

Social competences:
Understands the need for lifelong learning; can inspire and organize the learning process of other people. [K2_K01]
Is able to set priorities for the implementation of tasks specified by himself or others. [K2_K04]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: Written assessment of the lecture containing several open theoretical questions. Duration: 90 minutes.
Assessment criteria: 1 point is awarded for each task, points are awarded
with an accuracy of 0.25 points, a total of 5 points can be obtained.
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.
Classes: Assessment in the form of verification of research skills.
Assessment criteria: assessment criteria: 1 point is awarded for each task, points are awarded with an accuracy of 0.25 points, a total of 5 points are awarded.
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

Lectures:
Lecture 1 - The essence and concept of knowledge (science) and methodology
Elements of the knowledge system, division of science, general, detailed, descriptive and normative methodology.
Lecture 2 - The concept, essence and principles of scientific research
Objectives and functions of scientific research. Scientific research tasks. Principles of the scientific cognition process. Analysis and synthesis. Comparing and contrasting. Generalization and inference. Types of scientific research.
Lecture 3 - The essence and conditions of research problems
Research, scientific problem. Theses, hypotheses and their importance in scientific research.
Lecture 4 - Research methods, statistics and data analysis
Observational, experimental, computer simulation methods, analysis and criticism of literature sources. Discovering and examining relationships between variables. Verification of statistical hypotheses, tools for statistical data processing.
Lecture 5 - Organization and stages of research and development
Activities in the process of solving research problems. Formulation and justification of the research problem. Selection of methods, techniques and research tools.
Lecture 6 - The essence and concept of measurement in scientific research
Types of measurements, measurement errors, measurement reliability, statistical analysis of measurement results.
Lecture 7 - Developing a research procedure
Conducting research, organizing research results, their control and analysis, presenting research results.
Lecture 8 - Assessment
Written assessment of the lecture containing several open theoretical questions
Exercises:
Exercise 1 - Developing a research procedure, performing measurements, processing the results, drawing conclusions - buckling of a slender element.
Exercise 2 - Development of a research procedure, performance of measurements, preparation of results, conclusions - determining the coefficient of friction in a threaded connection.
Exercise 3 - Developing a research procedure, performing measurements, processing the results, drawing conclusions - tightening torque of a screw connection
Exercise 4 - Development of a research procedure, performance of measurements, preparation of results, conclusions - critical speed of the shaft
Exercise 5 - Development of a research procedure, performance of measurements, preparation of results, conclusions - positioning accuracy of the selected actuator.
Exercise 6 - Developing a research procedure, performing FEM computer simulation, developing results, drawing conclusions.
Exercise 7 - Development of a research procedure, performing a computer simulation - kinematic analysis, preparation of results, conclusions - operation of the selected mechanism.
Exercise 8 - Assessment
Completion of practical classes in the form of verification of the ability to develop a research procedure, perform research, develop research results, and draw conclusions.

Course topics

The program covers a broad introduction to scientific knowledge and research methodology. In the initial sections, students learn the fundamental concepts of the nature and structure of knowledge, as well as the classification of sciences. Different types of methodology—general, specific, descriptive, and normative—are also discussed, which helps in understanding the complexity and objectives of the research process.

The next thematic block focuses on scientific research, its aims, functions, and guiding principles. Participants become familiar with basic research tasks and the principles of the scientific inquiry process, such as analysis, synthesis, comparison, and inference, leading to an understanding of the different types of scientific research.

Following this, participants delve into issues related to research problems, formulating theses and hypotheses, and their role in scientific studies. Theoretical discussions are supplemented with an overview of research methods, including observational, experimental, computer simulation, and literature analysis. At this stage, students also learn how to identify and analyze relationships between variables and conduct

statistical hypothesis testing, which introduces them to data analysis and processing.

Later in the course, the organization and stages of research and development projects are covered, including the specifics of formulating research problems, selecting appropriate methods, techniques, and research tools, and applying them to problem-solving processes. This section also includes measurement-related issues, such as types of measurements, measurement errors, reliability, and statistical analysis of results, which are key elements of empirical research.

Subsequent sections of the course focus on developing research procedures, from conducting studies, analyzing and controlling results, to interpreting and presenting them. Students have the opportunity to gain hands-on experience with practical research processes, such as measurements and results processing (e.g., analyzing the buckling of elements, measuring the critical speed of shafts), as well as computer simulations, which include FEM analysis and kinematic analysis of selected mechanisms.

The course concludes with a review, verification of acquired knowledge, and assessment of practical skills in designing research procedures, conducting studies, and analyzing results.

Teaching methods

Lecture: Lecture with multimedia presentation.
Exercises: Methods of practical exercises and computer classes.

Bibliography

Basic:
1. Czesław Cempel, Nowoczesne zagadnienia metodologii i filozofii badań: wybrane zagadnienia dla studiów magisterskich, podyplomowych i doktoranckich: poradnik, Instytut Technologii Eksploatacji, Radom, 2005
2. Jan A. Wajand, Zarys problematyki badań naukowych w technice,Wydawnictwo Akademii Techniczno-Humanistycznej, Bielsko-Biała, 2009
3. Jerzy Apanowicz, Metodologia ogólna, Gdynia 2002.
4. Jan Kosmol, Wybrane zagadnienia metodologii badań, Wydawnictwo Politechniki Śląskiej, Gliwice, 2010.

Additional:
1. Wiesław Leszek, Wybrane zagadnienia metodyczne badań empirycznych, Instytut Technologii Eksploatacji - Państwowy Instytut Badawczy, Radom, 2006.
2. Wojtkowiak D., Talaśka K., Fierek A.: The application of the Finite Element Method analysis in the process of designing the punching die for belt perforation, IOP Conferences: Materials Science and Engineering 776: 012057, 2020.
3. 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.
4. Wilczyński D., Berdychowski M., Talaśka K., Wojtkowiak D., Experimental and numerical analysis of the effect of compaction conditions on briquette properties. Fuel, 2021, vol. 288, s. 119613-1-119613-19

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	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)	20	1,00