COURSE DESCRIPTION CARD - SYLLABUS

Course name
Selected computational problems in mechatronics [N1Mech2>WZMwM]

Course

Field of study
Mechatronics

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
part-time

Requirements
compulsory

Number of hours

Lecture
8

Laboratory classes
8

Other
0

Tutorials
8

Projects/seminars
0

Number of credit points

4,00

Coordinators

Lecturers

Prerequisites

Basic knowledge of mathematics, physics, mechanics;

Course objective

Understanding mathematical modeling methods of processes related to the broadly understood field of mechatronics.

Course-related learning outcomes

Knowledge:
he student has advanced knowledge in computational methods for mechatronics issues, particularly in solving differential equations, discrete equations, determining eigenvalues of matrices, eigenvectors, and modal matrices, as well as solving basic nonlinear ordinary and partial differential equations.
The student has advanced knowledge in computational methods that enable mathematical modeling of the mechanical, electrical, and control properties of mechatronic devices, as well as describing digital discrete, impulsive, and nonlinear systems, as well as discrete algorithms.

Skills:
The student is able to gather information from the internet, literature, databases, and other appropriately selected sources (mainly in English) in the field of mechatronics; they can integrate the

obtained information, interpret it, draw conclusions, and formulate and justify opinions.
They are able to apply mathematics for basic analysis of discrete and nonlinear systems. They can find solutions to basic differential equations, nonlinear ordinary, partial, and discrete equations. They are able to use mathematics for modeling the properties of components in mechatronic devices. They can develop a mathematical description of the dynamics of the constituent elements of mechatronic devices.
The student is able to identify directions for further learning and carry out the process of self-education.

Social competences:
Understands the need for learning and acquiring new knowledge, as well as continuously deepening it; is able to inspire and organize the learning process for others. Can set priorities to achieve a task defined by oneself or others. Able to collaborate and work in a group, taking on different roles within it.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture: Written test - 15 questions - (pass if at least 50.1% correct answers are achieved). Up to 50.0% - fail, from 50.1% to 60.0% - satisfactory, from 60.1% to 70.0% - satisfactory+, from 70.1% to 80% - good, from 80.1% to 90.0% - good+, from 90.1% - very good.
Tutorials: Written test - 4 tasks - (pass if at least 50.1% correct answers are achieved). Up to 50.0% - fail, from 50.1% to 60.0% - satisfactory, from 60.1% to 70.0% - satisfactory+, from 70.1% to 80% - good, from 80.1% to 90.0% - good+, from 90.1% - very good.
Laboratory: Pass based on oral or written responses concerning the content of each laboratory exercise, checking the results of work for each laboratory exercise according to the instructions of the laboratory instructor (e.g., in the form of a test at the end of the class - 3 tasks). In order to pass the laboratory, all exercises must be completed (positive grade for responses and tests).

Programme content

Basic knowledge of computational methods.
Selected computational methods for solving: nonlinear equations, systems of linear and nonlinear algebraic equations; evaluating definite integrals; approximation and interpolation problems; initial and boundary value problems.

Course topics

Lecture:
1. Introduction to engineering computations. Estimating the numerical accuracy of algorithms for solving computational problems.
2. Determining the length of elements in complex mechanisms - numerical methods: bisection, Newton's method.
3. Application of interpolation for single-variable functions (Lagrange interpolation polynomial, cubic spline functions, spline interpolation).
4. Calculation of areas, static moments, moments of inertia of planar figures, volume, mass, and weight of three-dimensional elements; evaluation of integrals that cannot be solved analytically and those appearing in engineering problems - elliptic integrals - numerical integration (composite trapezoidal rule, composite Simpson's rule).
5. Discrete approximation in the least-squares sense.
6. Determining the motion of a mathematical and physical pendulum, introduction to deterministic chaos - numerical solution of boundary problems (Euler’s methods, Runge-Kutta methods for a single equation, and Runge-Kutta methods for systems of differential equations).
7. Numerical solutions to one-dimensional boundary problems: shooting method, finite difference method.
Tutorials:
1. Estimating the numerical accuracy of algorithms for solving computational problems.
Preparing algorithms and testing solutions for the discussed topics.
2. Determining the length of elements in complex mechanisms - numerical methods: bisection, Newton's method.
3. Application of interpolation for single-variable functions (Lagrange interpolation polynomial, cubic spline functions, spline interpolation).

4. Calculation of areas, static moments, moments of inertia of planar figures, volume, mass, and weight of three-dimensional elements; evaluation of integrals that cannot be solved analytically and those appearing in engineering problems - elliptic integrals - numerical integration (composite trapezoidal rule, composite Simpson's rule).
5. Discrete approximation in the least-squares sense.
6. Determining the motion of a mathematical and physical pendulum, introduction to deterministic chaos - numerical solution of boundary problems (Euler’s methods, Runge-Kutta methods for a single equation, and Runge-Kutta methods for systems of differential equations).
7. Numerical solutions to one-dimensional boundary problems: shooting method, finite difference method.

Laboratory

Preparation of computer programs based on the knowledge acquired in lectures and the algorithms developed during tutorials. Testing the prepared software.

Topics covered in laboratory sessions:
1. Introduction to computer programs used for developing computational software.
2. Determining the length of elements in complex mechanisms - numerical methods: bisection, Newton's method.
3. Application of interpolation for single-variable functions (Lagrange interpolation polynomial, cubic spline functions, spline interpolation).
4. Calculation of areas, static moments, moments of inertia of planar figures, volume, mass, and weight of three-dimensional elements; evaluation of integrals that cannot be solved analytically and those appearing in engineering problems - elliptic integrals - numerical integration (composite trapezoidal rule, composite Simpson's rule).
5. Discrete approximation in the least-squares sense.
6. Determining the motion of a mathematical and physical pendulum, introduction to deterministic chaos - numerical solution of boundary problems (Euler’s methods, Runge-Kutta methods for a single equation, and Runge-Kutta methods for systems of differential equations).
7. Numerical solutions to one-dimensional boundary problems: shooting method, finite difference method.

Teaching methods

Multimedia presentation illustrated with examples, presentation of solutions to tasks using numerical methods, practical student activities - preparing software to solve problems, solving tasks.

Bibliography

Basic:
1. Fortuna Z., Macukow B., Wąsoski J., 2001, Metody numeryczne. NT, Warszawa
2. Burden R. L., Faires J. D., 1981, Numerical Analysis. PWS-KENT, Boston 1981

Additional:
1. Uścıłowska A., 2009, Ćwiczenia laboratoryjne z metod numerycznych. Wydawnictwo Państwowej Wyższej Szkoły Zawodowej w Pile, Piła.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	24	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	76	3,00