Annex No. 2.10

Faculty / Institute: Faculty of Mechatronics

study programme: Mechatronics

leading discipline: mechanical engineering

educational profile: general academic

level of study: first-cycle engineering studies

Senate resolution number* 58/2025/2026 of 26 may 2026

No.	Course	Programme learning outcomes	Programme content	Methods of verifying learning outcomes
1	Mathematics I	K_W01, K_U29	Elements of mathematical logic, tautologies of classical propositional and predicate calculus. Numerical sequences. Monotonicity of a sequence. Numerical series and convergence criteria. Classification and properties of functions. Elementary functions. Limit of a function. Continuous functions. Derivative of a function of one variable and its applications. Indefinite integral of a function of one variable.	Exercises – two written tests; Lecture – written exam covering application of theory in problems. Pass mark: 50% of points.
2	Mathematics II	K_W01, K_U29	Indefinite and definite integral of a function of one variable. Applications of definite integrals in physics and geometry. Improper integrals. Differential and integral calculus of functions of several variables. Differential equations with separable variables. Complex numbers. Matrices and determinants. Systems of linear equations.	Exercises: written test, which may be split into two parts (pass from 50%). Lecture – graded credit comprising two parts: theoretical and problem-solving. Pass mark: 50% of points.
3	Introduction to Mechatronics (e)	K_W07, K_W08, K_W23 K_K02, K_K06	History and evolution of mechatronics in the world and in Poland. Mechatronic systems and their areas of application. Automotive, aviation, industrial, military, medical, consumer, construction, and safety mechatronics. Introduction to basic system components and operating principles.	In-lecture test credits, presentations. Pass mark: 50% of points.

4	Engineering Materials	K_W02, K_W03, K_U01, K_U29, K_K02	Selected topics in metal physics. General information on metals, alloys, and structural non-metallic materials. Wear mechanisms and corrosion of metals and alloys. Basic properties of technical materials. Destructive/non-destructive and direct/indirect material testing methods. Material design methods and principles for determining effective properties. Life cycle and environmental aspects of materials.	Exercises, laboratories: written tests, entry quizzes (pass from 50%). Lecture – Semester 1: written test (pass from 50%); Semester 2: written exam (pass from 50%).
5	Engineering Drawing + CAD (e)	K_W13, K_U11, K_U29	Geometric shaping of technical forms. Elements of engineering drawing. Creating technical documentation: detail and assembly drawings. Orthographic and axonometric projection. Representation and dimensioning of machine elements. Surface texture designation. Tolerances and fits, surface roughness, form and position deviations. Assembly diagrams and drawings. Engineering drawing in electrical and electronic engineering. Pneumatic and hydraulic diagrams. Fundamentals of computer-aided design for 2D and 3D geometric representation, calculations, and simulations. Basics of AutoCAD and SolidWorks.	Lecture – project and exam, pass above 50%. Exercises – homework, project >50% – average of grades. Laboratory – homework, project ≥50% – average of grades.
6	Programming (e)	K_W19, K_W20, K_U21, K_U29	Algorithmic approach to problem solving, including flowcharts and pseudocode. Program structure in high-level languages (with particular emphasis on Python). Input/output instructions and working with data. Use of basic data types (numbers, strings, Boolean type) and data structures (lists, tuples, dictionaries, sets). Introduction to modules and standard libraries and their applications. Control statements: conditional (if, elif, else) and iterative (for, while). Creating functions, passing arguments, returning values, and code organisation.	Lecture – Semester 1: written test (pass from 50%); Semester 2: written test (pass from 50%). The test consists of writing computer programmes.
7	Mechanics I	K_W02, K_W09, K_U29	Fundamentals of vector calculus. Basic concepts and laws of mechanics. Concurrent plane and spatial force systems. Arbitrary spatial and plane force systems: equilibrium conditions. Friction: laws of friction, classification of friction forces, sliding and rolling friction, belt friction. Centre of parallel forces. Trusses: plane trusses, rigidity conditions. Cremona and Ritter methods for solving trusses.	Lecture credit: exam on theoretical topics in vector calculus and statics. Exercise credit: two written tests on problem-solving in vector calculus and statics (pass from 50%).

8	Fundamentals of Robotics (e)	K_W05, K_U02, K_U03, K_U29	Programming fundamentals, basics of construction and operation of simple wheeled robots with a support wheel or ball, and simple data acquisition systems. Introduction to robotics. Introduction to the Arduino platform and available peripherals. Algorithms for robot programming; Introduction to robot programming.	Lecture: written exam – open questions, 50% required. Exercises: programming test – individual task, 50% required.
9	Electrical Engineering and Electronics	K_W17, K_W21, K_U17, K_U24, K_U29	Elements of electrical circuits. Basic laws and properties of electrical circuits. Description of electromagnetic fields – Maxwell's equations. Single-phase sinusoidal AC circuits: RMS value, average value, power, and work in AC circuits. Circuits containing RLC elements. Passive and active electrical filters. p-n junction, diode, bipolar and unipolar transistors. Transistor amplifiers. Digital circuits: basic logic gates, properties and parameters of combinational and sequential digital circuits. Encoders and decoders. Multiplexers and demultiplexers. Adders and subtractors. Registers and RAM circuits. Data transmission and control circuits. Counters.	Written exam. Pass from 50%. Laboratory: projects and tests, grade average, pass from 50%.
10	Artificial Intelligence in Mechatronics (e)	K_W19, K_W20, K_U02, K_U21, K_U29	Introduction to AI methods and their applications in mechatronic systems (robotics, automation, IoT). Fundamentals of data analysis and machine learning. Use and testing of AI tools to support system design, programming, and analysis. Assessment of their effectiveness and limitations. Fundamentals of process automation using AI (workflow, tool integration) and applications in Industry 4.0. Ethical issues and data security.	Lecture: credit in the form of a 20-point test, pass threshold 12 points. Laboratory: based on projects, grade average (pass from 50%).
11	Fundamentals of Automation	K_W04, K_U02, K_U03, K_U29	Basic components of a control system. Signals in control systems and their classification. Basic control systems. The controller as the most important element of a closed-loop control system. Three-term PID controller and its algorithms. Mathematical modelling of dynamic systems. Transfer function. Mathematical models of control systems. Experimental methods for determining dynamic properties of automation element models. Connections of automation system elements. Controllers and control systems. Assessment of automation system control, Ziegler-Nichols method.	Lecture – written exam, pass from 50%. Laboratories: credit based on test grades and points collected by the student during the semester and lecture attendance, pass from 50%.
12	Fundamentals of Enterprise Management in ERP (e)	K_W25, K_U22, K_U28, K_K01, K_K03	Basic areas of enterprise operation; Production process planning; Preliminary analysis of planning results and production capacity; Fundamentals of creating and executing production orders.	Graded credit – evaluation of a complete production planning and management procedure example; lecture: written credit or project-based credit using ERP systems.

13	Fundamentals of Numerical Methods and FEM (e)	K_W10, K_U29	Introduction to numerical computation. Numerical solution of systems of linear equations and nonlinear equations. Numerical differentiation. Numerical integration. Fundamentals of the Finite Element Method (FEM). Application of Matlab, Comsol, and other software for implementing numerical methods, including FEM.	For lecture credit, students are required to prepare at least 3 computational tasks (projects). Final grade is the average of at least 3 computational projects with equal weights. Laboratory: computational tasks in computer software and preparation of reports; final grade is the average of grades (pass from 50%).
14	Mechanics II	K_W02, K_W09, K_U07, K_U29	Kinematics: description of point motion, velocity and acceleration, description of relative motion, rigid body motion, angular velocity and acceleration. Dynamics: fundamentals of dynamics of a material point, vibrations of a material point, curvilinear motion of a material point, momentum and angular momentum of a material point, work of a force and kinetic energy of a material point, dynamics of a system of material points, kinetic energy of a system of material points, dynamics of plane translational and rotational motion of a rigid body.	Lecture credit based on two written tests on theoretical topics in kinematics and dynamics. Exercise credit based on two written tests on problem-solving in kinematics and dynamics (pass from 50%).
15	Strength of Materials (e)	K_W09, K_U08, K_U29	Analysis of stress and strain states. Simple load cases – tension and compression, shear, torsion, bending. Buckling, stability of rods. Combined loading. Selected strength hypotheses. Fatigue strength. Energy methods. Shell theories.	Lecture – written exam, pass >50%. Exercises – written test, pass >50%. Laboratory – lab reports, 100%.
16	Control Theory	K_W04, K_U02, K_U03, K_U04	Description of process dynamics using the state space method. Concepts of controllability and observability of dynamic systems. Elements of Boolean algebra. Logical operations and logical functions. Design of combinational circuits. Design of sequential circuits. PLC programming languages.	Written or oral exam with open questions covering lecture and exercise content, pass from 50%.
17	Theory of Machines and Mechanisms	K_W09, K_W11, K_U25, K_U29	Introduction to the theory of machines and mechanisms (TMM). Structure of mechanisms. Kinematic analysis of planar mechanisms. Graphoanalytical method. Kinematic analysis of transmissions. Determination of inertia forces in mechanisms. Static and kinetostatic analysis of mechanisms without friction. Friction in kinematic pairs of mechanisms. Static and kinetostatic analysis of mechanisms with friction.	Lecture: written credit – completion of three tasks covering lecture and exercise topics, subject to a positive grade in exercises. Laboratory exercises: average of quiz grades, assessment of performance of individual exercises, technical documentation (portfolio) of a minimum of 40 tasks.

18	Metrology and Computer-Aided Measurement (e)	K_W21, K_W22, K_U23, K_U24, K_U29	Fundamentals of metrology. Measurement methods including optical measurement methods, construction and operating principles of selected measuring instrument groups, selection of instruments for measurements, conducting measurements, quality measurement of measuring instruments and their calibration. Error calculus. Basic types of continuous random variable distributions, including the normal (Gaussian) distribution and t-Student distribution. Computer-based measurement systems, use of LabVIEW software. Coordinate measurement technology and measurement of machine elements with complex geometry. Methods and approaches for evaluating geometrical surface structure. Dimensional analysis, form and position deviations, roughness, waviness, and methods for measuring these parameters.	Graded credit – lecture: credit based on written test (pass from 50%); laboratory – average grade of reports from completed laboratory/measurement exercises.
19	Manufacturing Processes and Additive Technologies (e)	K_W14, K_W15, K_U14, K_U18, K_U29	Manufacturing processes and shaping of material properties. Subtractive machining and other technologies for shaping the geometric form of materials, plastic forming. Machining methods, cutting parameters, geometry of the cut layer. Physical aspects of the cutting process, chip formation, wear and durability of cutting tools, forces and power during cutting. Construction of cutting tools, tool materials, cutting edge geometry. Classification of plastic forming processes: rolling, drawing, forging, sheet metal stamping. Cutting and joining of materials, application of laser, plasma, and other processing methods, welding, resistance welding, brazing. Surface treatment and thermochemical processing. Coating and plating technologies. Electrochemical, chemical, and electrolytic coating methods, typical coatings: galvanising, chromium plating, nickel plating.	Graded credit – written test or written credit covering the material covered in class (pass from 50%).
20	Fundamentals of Machine Design	K_W06, K_W11, K_U05, K_U11, K_U29	Introduction to the design process: design with respect to strength, stiffness, and dynamic criteria. Damage to structural elements, classification and characterisation of damage. Wear of machine elements, tribological issues. Fatigue process. Classification and characterisation of detachable and non-detachable joints in machine construction. Design of axles and shafts. General principles of bearing and coupling of shafts.	Lecture: written exam with open questions (pass from 50%). Exercises: written credit test, pass >50%.

21	Fluid Mechanics (e)	K_W09, K_U07, K_U29	Basic physical properties of fluids. Fluid mechanics equations: mass and momentum balance equations. Ideal fluid model: Clapeyron equation, Euler equations; Bernoulli equation and its applications. Viscous Newtonian fluid model: Navier-Stokes equations. Fluid statics: basic equations, fluid pressure on a wall, equilibrium conditions of bodies submerged in liquid; Archimedes' principle, conditions for floating of solid bodies. Fluid flows; description of viscous fluid flow through a pipe, potential flows.	Lecture credit: exam on theoretical topics (pass from 50%). Exercise credit based on two written tests on problem-solving in fluid mechanics.
22	Hydraulics and Pneumatics (e)	K_W06, K_W12, K_U13, K_U29	Compressors and compressed air distribution. Valves. Pneumatic linear and rotary drives. Pneumatic grippers. Basic control systems. Hydraulic drives. Energy-generating components in hydrostatic drives – hydraulic displacement pumps, displacement motors, cylinders. Parameters of pump system operation.	Graded projects from hydraulic and pneumatic sections. Average of two sections (pass from 50%).
23	Microprocessor Systems	K_W17 i K_W18, K_W19, K_W20, K_U03, K_U11	Fundamentals of construction and operation of microprocessor systems and microcontrollers. Architecture, memory, communication interfaces, and input/output handling. Programming of microcontrollers in high-level languages and integration with sensors and actuators. Creating simple control systems. Applications in mechatronic systems, automation, and IoT. Fundamentals of circuit diagnostics and testing.	Lecture: written exam – 50% of points required. Laboratory: grade from reports of completed exercises 60% of grade, grade for activity in class – 40% of grade.
24	Computer Networks and IoT Technologies (e)	K_W08, K_W19, K_W20, K_U19, K_U20, K_U21, K_U29	Fundamentals of computer network construction and operation and network operating systems. Communication models (ISO/OSI, TCP/IP) and principles of data transmission. Physical and network access layer: transmission technologies, wired and wireless media, including IoT solutions (e.g. Wi-Fi, Bluetooth, LPWAN). Ethernet local area networks, LAN switches, and fundamentals of router operation. Network and transport layer: IP addressing (IPv4/IPv6), subnets, routing (CIDR/VLSM), TCP and UDP protocols. Application layer: basic network services (HTTP, FTP/SCP, SMTP, IMAP/POP, SSH). IoT device integration, M2M communication, and fundamentals of network security and management.	Lecture: written exam, answers to 5 questions from approx. 100 questions given to students in advance for preparation. Exercises: average grade from tasks completed in class and short entry quizzes (pass from 50%).

25	Embedded Systems and IoT (e)	K_W18, K_W19, K_W20, K_U03, K_U04, K_U09	Architecture and design of embedded systems, microcontrollers, sensors, and actuators. Device communication in a network, basic IoT data transmission protocols, integration of devices with the cloud and applications. Programming, configuration, and commissioning of smart devices and monitoring systems. Security, reliability issues, and practical IoT applications in automation, industry, and intelligent systems.	Lecture: written exam – 50% of points required. Laboratory: grade from reports of completed exercises 60% of grade, grade for activity in class – 40% of grade.
26	Programmable Logic Controllers	K_W04, K_W06, K_U19, K_U20, K_U21, K_U29	Introduction to programmable logic controllers (PLC). PLC hardware: controller modules, central processing unit CPU, digital input/output modules, analogue input/output modules, controller power supplies. Recommendations and standards for programming languages (IEC 61131 standard). Graphical programming languages: Ladder Diagram LD, Function Block Diagram FBD. Text-based programming languages: Instruction List IL, Structured Text ST. Construction and programming of Siemens, Rockwell, Omron, and Unitronics industrial controllers. Industrial fieldbus systems: RS232/485, CAN, Profibus.	Lecture: written exam – 50% of points required. Laboratory: grade from reports of completed exercises 60% of grade, grade for activity in class – 40% of grade.
27	Technological Process Design (e)	K_W15, K_U10, K_U16, K_U25, K_U29	Technological production preparation: selection of input material forms and properties, development of the technological process, selection of production machinery and equipment, selection of workshop aids, determination of time standards, determination of costs. Practical discussion of production processes: metal processing: rolling, stamping, casting, joining: welding and types, brazing, resistance welding, manufacturing of composite elements and methods, machining, glass processing. Analysis of production company operational problems and their resolution through production changes.	Project: completion of the project and consultations at all project stages (grade is the average of grades). Exercises: reports from tasks solved in class. Lecture: written test, 60% of points required to pass.
28	Design and Control of Robotic Systems (e)	K_W04, K_W05, K_W06, K_W12, K_W19, K_U11, K_U29	Design and control of robotic systems – fundamentals of robot kinematics and dynamics, manipulator structures, and mobile systems. Methods for modelling and simulation of robotic systems. Control algorithms (PID, adaptive and intelligent control), trajectory planning, and integration with vision systems and sensors. Programming of industrial and mobile robots and their application in automation and Industry 4.0.	Lecture: written credit – 50% of points required. Laboratory: grade from reports of completed exercises 60% of grade, grade for activity in class – 40% of grade.

29	CNC Machines and CAM (e)	K_W16, K_U09, K_U15, K_U24	Construction and operating principles of selected numerically controlled machine tools. Coordinate systems in CNC machines, characteristic points of machine tools, methods for setting the workpiece zero. Discussion of example programmes for turning and milling, development of the technological process, selection of cutting tools for specific machining tasks. Discussion of most commonly used cycles, e.g. drilling, facing, threading cycles. Introduction to CNC machine programming using CAM software. Skills for developing an NC programme for a selected part, preparing the machine for operation, and manufacturing the part.	Graded credit – written test or multiple-choice test covering lecture material, and evaluation of projects completed in the CAM environment and in ISO code (pass from 50%).
30	Operation of Mechatronic Systems (e)	K_W06, K_W07, K_W08, K_U06, K_U07, K_U12, K_U24, K_U29	Physicochemical fundamentals of machine operation. Analysis of basic operational concepts. The essence of Industry 4.0. Machine operation strategies. Use of machines. Machine servicing. Operational control. Fundamentals of machine diagnostics. Utility programs in maintenance. Applications for maintenance engineers. Operational design.	Written credit, pass from 51%. Laboratory: average grade from reports, pass from 50%.
31	Diploma Seminar	K_U26, K_U27, K_U28, K_U29, K_U30, K_K01, K_K02, K_K06	Principles of writing and formatting an engineering diploma thesis. Methodology for searching and verifying literature sources and citation rules. Intellectual property protection and copyright law. Formulating the aim, scope, and thesis statement. Methods of scientific information analysis and synthesis. Methodology of engineering research. Principles of preparing technical documentation and presenting results. Preparation of a multimedia presentation for the defence. Professional ethics and non-technical aspects of engineering activity. Presentations of diploma thesis progress. Mock diploma thesis defences.	Diploma thesis.
32	Fundamentals of Entrepreneurship (e)	K_W23, K_W25, K_U29, K_K05	Basic forms of economic and labour market activity; Employment under a contract of employment, contract for specific work, mandate contract, self-employment, B2B; Sole trader activity, methods of setting up and registering a business; General partnership, civil partnership; Limited liability companies; Joint-stock companies, stock exchanges, share prices, currencies and cryptocurrencies; Limited partnerships; Cooperatives; State-owned enterprises; Private equity, crowdfunding.	Completion of interim assignments enables assessment of the degree and quality of learning outcomes (pass from 50%).

33	Law and Intellectual Property Protection (e)	K_W23, K_W24, K_U29, K_K02, K_K04	Introduction to the topic. Origins of intellectual property protection, explanation of concepts. Structure and functioning of the Patent Office. From invention to patent. Utility models. Copyright law, types of works protected by copyright, rights related to copyright, author's rights, works created in employment, co-authors. Trademark protection law.	Credit: written test – pass >50%.
34	Foreign Language	K_U05	In the grammar component, students consolidate their knowledge of tenses (Present, Past, Future), modal verbs, and conditional forms, including mixed conditionals. Lexical topics focus on vocabulary from the fields of mechanics and electronics — covering types of mechanical and permanent joints, engine construction and operation, fundamentals of electrical power supply, and electronic waste management. The course also addresses modern technologies, artificial intelligence (technical and ethical aspects), and intelligent security systems. Vocabulary development encompasses collocations, idioms, and word formation (prefixes and suffixes).	Semester 1 credit: preparation of a literature review and chapter outline for a paper on a given topic. Semester 2 credit: preparation of a preliminary overview of the whole paper, presentation of the paper to the group. Written examination, passing grade above 50%.
35	Physical Education	K_K03	Discussion of health and safety regulations during Physical Education classes, familiarization with the course completion requirements, the SWF regulations, and the rules for using a given sports facility. Exercises developing and strengthening different muscle groups of the body, shaping correct posture. Specialized exercises depending on the sports discipline chosen by the student.	Assessment/completion in accordance with the sports discipline chosen by the student.
36	Professional Internship	K_U24, K_U28, K_K03	Familiarisation with the description, programme, and rules of the professional internship sent by the Programme Internship Supervisor; selection of the internship location, employer, institution, or enterprise; notification to the Programme Internship Supervisor of the location, scope, subject matter, and dates of the internship and obtaining substantive approval; completion of the internship and record-keeping in the internship logbook, concluded with a written opinion from the internship employer; gaining an understanding of the specifics of the mechatronics engineer's work in various positions and industries.	Submission to the Internship Coordinator of: the internship diary and opinion, or the traineeship diary and opinion, or a certificate of employment with job description, or a certificate of business activity with a list of completed projects.
MODULE BLOCK: Mechatronics in Production Systems				

1	Computer-Aided Engineering (e)	K_W06, K_W13, K_U06, K_U11, K_U29	Graphical support for engineering work. Integrated environment for supporting engineering work. CAD – computer-aided design – introduction; CAM – computer-aided manufacturing – introduction. Application of SolidWorks software in engineering work. Modelling and simulation in SolidWorks design. Classification of engineering problems. Computer-aided engineering systems as an element of the Scheer model.	Written credit (pass from 50%); laboratory: project completion, grade average (pass from 50%).
2	Monographic Lecture. Modern Production Systems (e)	K_W08, K_W09, K_U29	Modern production systems – overview of contemporary manufacturing concepts and technologies, including Industry 4.0, production digitalisation, and process automation and robotisation. Cyber-physical systems, the Internet of Things (IoT) in industry, integration of production systems, and data management. Smart Factory, flexible production systems, additive technologies, and the use of artificial intelligence in optimising manufacturing processes.	Written test or presentation (pass from 50%).
3	Production Process Automation	K_W04, K_W05, K_U02, K_U03, K_U29	Structure of numerical control, CNC machine tool coordinate system, machining programme structure, working movements. Mechanisation, automation, and robotisation of production processes. Functional structure of numerical control and automatic regulation. Numerical control and automatic regulation. Technical capabilities of automation systems. Structure and functions of automated production systems.	Assessment of quality of interim work related to the topics covered (pass from 50%).
4	Mechatronic System Design	K_W06, K_W07, K_W08, K_U04, K_U05, K_U06, K_U10, K_U11, K_U29	Main objectives and features of mechatronic system design. Principles of designing mechatronic devices and systems. Main stages of mechatronic system design. Example tools used for designing mechatronic systems. Models of mechatronic system elements. Multi-body system models. Dynamic models. Control techniques in mechatronic systems: application of PEC microcontrollers in mechatronic systems.	Written or oral exam with open questions covering lecture and laboratory content (pass from 50%).
5	Control of Automated Production Systems (e)	K_W06, K_W12, K_W18, K_U12, K_U13, K_U29	Principles of operation and design of control systems in production processes. Programming and configuration of PLC controllers, SCADA systems, and HMI interfaces. Integration of automation devices (sensors, drives, robots) in complex production lines. Process regulation and supervision methods, diagnostics, and optimisation of production system operation taking into account the Industry 4.0 concept.	Lecture: written credit – 50% of points required. Laboratory: grade from reports of completed exercises 60% of grade, grade for activity in class – 40% of grade.

6	Sales, Distribution and Production in ERP Systems (e)	K_W20, K_W25, K_U22, K_U28	Operation of integrated ERP-class systems in the areas of sales, logistics, and production. Business process modelling, order management, production planning (MRP/MRP II), warehouse management, and supply chain. Enterprise data integration, information analysis, and the use of ERP systems for process optimisation and management decision-making.	Graded credit – evaluation of a complete production planning and management procedure (pass from 50%).
7	Digital Signal and Image Processing in Production Engineering	K_W22, K_U07, K_U23, K_U29	Fundamentals of analogue-to-digital and digital-to-analogue conversion. 1D and 2D correlation. 1D and 2D convolution. 1D and 2D Fourier Transform. Inverse Fourier Transform. Point and context operations on digital images. Interpolation and basic geometric image transformations. Mathematical morphology applied to binary images.	Laboratory: two written tests in which students solve problems. Pass from 50% of points. Lecture – exam (pass from 50%).
8	Mechatronic Team Project I	K_W06, K_W08, K_W12, K_U01, K_U03, K_U09, K_U29	Design and development of concepts for modern mechatronic systems in a production environment; development and adoption of design and construction assumptions for automated workstations and production lines; conducting functional and conceptual analysis of the system; development of sketches and models of structural solutions for mechatronic systems and their assemblies (drive, control, sensing); selection of appropriate components and structural features taking into account efficiency, reliability, and integration with Industry 4.0 systems.	Laboratory: preparation of projects in which students solve practical tasks. Pass from 51% of points. Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).
9	Sensor and Measurement Systems in Mechatronics (e)	K_W06, K_W08, K_W13, K_U06, K_U11, K_U29	Construction and operating principles of sensors and measurement systems used in mechatronic systems. Methods for measuring physical quantities (temperature, pressure, displacement, force, velocity), signal processing, and acquisition. Communication interfaces, vision systems, and integration of sensors with control systems. Accuracy analysis, calibration, and diagnostics of measurement systems in industrial applications.	Lecture: written credit – 50% of points required. Laboratory: grade from reports of completed exercises (pass from 50%).
10	Mechatroniczny projekt zespoowy II	K_W07, K_W08, K_W13, K_U06, K_U09, K_U25, K_U29, K_K02	Design and development of concepts for modern mechatronic systems in a production environment; development and adoption of design and construction assumptions for automated workstations and production lines; conducting functional and conceptual analysis of the system; development of sketches and models of structural solutions for mechatronic systems and their assemblies (drive, control, sensing); selection of appropriate components and structural features taking into account efficiency, reliability, and integration with Industry 4.0 systems.	Laboratory: preparation of projects in which students solve practical tasks. Pass from 51% of points. Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).

11	Specialisation Diploma Laboratory	K_W06, K_U04, K_U05, K_U07, K_U28, K_U29	General requirements for the diploma thesis and basic guidelines. Techniques for writing a scientific paper. Formulating the thesis topic. Methods for searching literature and data sources. Writing the introduction. Defining research objectives, formulating research problems and conclusions. Processing and analysis of research results. Preparing presentations and presenting work results. Presentation of thesis chapters.	Semester 1 credit: preparation of a literature review and chapter outline for a paper on a given topic. Semester 2 credit: preparation of a preliminary overview of the whole paper, presentation of the paper to the group.
MODULE BLOCK: Unmanned Systems Engineering				
1	Mobile Platform Programming	K_W05, K_W19, K_U21, K_U29	Implementation of software aimed at controlling the motion of mobile land platforms. Designed and programmed platforms will also have measurement data acquisition systems, application of various types of manipulators, and physical and graphical user interfaces. Secure communication via the Internet with external systems/applications and implementation of mini-projects.	Verification of outcomes: systematic work – implementation of mini-projects, practical written test (pass from 50%).
2	Computer-Aided Design CAD (e)	K_W13, K_U09, K_U29	Overview of computer-aided design tools in CAD systems, 3D modelling, dimensioning principles, basic CAD, CAE, CAM, CE concepts, 3D modelling, FEM-based strength analysis. Laboratories: CAD software working techniques, creation of drawings using learned working techniques.	Laboratory: preparation of projects in which students solve practical tasks. Pass from 51% of points. Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).
3	Monographic Lecture. Characteristics and Operation of Unmanned Systems (e)	K_W08, K_W09, K_U29	Fundamentals of construction and operation of unmanned objects, UAS systems, navigation systems, aviation law, operational procedures, flight execution rules.	Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).
4	Aerodynamics and Flight Mechanics (e)	K_W06, K_W10, K_W12, K_W18, K_U12, K_U13, K_U29	Propulsion systems in flying objects. Earth's atmosphere, Archimedes' principle. Flight mechanics: forces acting on a flying object, Bernoulli's principle. Propulsion systems used in unmanned aerial vehicles. Electric drives. Aerodynamic force calculations.	Laboratory: grade from reports of completed exercises – weight 50%; grade for activity in class – weight 50%.
5	Fundamentals of Digital Signal and Image Processing (e)	K_W22, K_U07, K_U23, K_U29	Fundamentals of analogue-to-digital and digital-to-analogue conversion. 1D and 2D correlation. 1D and 2D convolution. 1D and 2D Fourier Transform. Inverse Fourier Transform. Point and context operations on digital images. Interpolation and basic geometric image transformations. Mathematical morphology applied to binary images.	Laboratory: two written tests in which students solve problems. Pass from 50% of points. Lecture – exam (pass from 50%).

6	Drives and Control of Unmanned Systems (e)	K_W06, K_W12, K_W18, K_U12, K_U13, K_U29	Propulsion systems in technical objects. Mechanical, pneumatic, and hydraulic drives in machine construction. Mechanical transmissions: gear, chain, belt, friction, and special types. Strength calculations for selected mechanical transmission elements. Drone and other unmanned device drives.	Laboratory: written tests in which students solve practical tasks. Pass from 50% of points. Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).
7	3D Printing in Prototyping (e)	K_W14, K_U09, K_U29	Overview of additive techniques, overview of various 3D printer designs, creating a model for printing, 3D printing, FDM, FFF, SLA, LOM printing techniques, printing and calibration errors, characterisation of printed materials. Laboratory: preparation of 3D elements for printing using specialist computer software.	Laboratory: preparation of projects in which students solve practical tasks. Pass from 51% of points. Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).
8	Design of Unmanned Platforms	K_W06, K_W11, K_U09, K_U11, K_U29	Construction of individual elements of unmanned systems including fuselages, wing and tail unit construction, undercarriage design, analysis of flight drag balance and performance.	Laboratory: preparation of projects in which students solve practical tasks. Pass from 51% of points. Lecture – exam (pass from 50%).
9	Mechatronic Team Project I	K_W06, K_W08, K_W12, K_U01, K_U03, K_U09, K_U29	Design and development of a simple unmanned system structure; development and adoption of design and construction assumptions, functional and conceptual analysis, development of structural design sketches for the unmanned vehicle and its functional assemblies, selection of structural features.	Laboratory: preparation of projects in which students solve practical tasks. Pass from 51% of points. Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).
10	Mechatronic Sensor Systems (e)	K_W06, K_W07, K_W08, K_U04, K_U05, K_U06, K_U10, K_U11, K_U29	Main objectives and features of mechatronic system design. Principles of designing mechatronic devices and systems. Main stages of mechatronic system design. Example tools used for designing mechatronic systems. Models of mechatronic system elements. Multi-body system models. Dynamic models. Control techniques in mechatronic systems: application of PEC microcontrollers in mechatronic systems.	Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).

11	Mechatroniczny projekt zespoowy II	K_W07, K_W08, K_W13, K_U06, K_U09, K_U25, K_U29, K_K02	Design and development of a simple unmanned system structure; Development of structural features of the unmanned system, design and construction work, selection of drives and control systems, selection of additional equipment elements, programming of necessary devices.	Laboratory: preparation of projects in which students solve practical tasks. Pass from 51% of points. Lecture: graded credit based on written test and/or prepared presentation (pass from 50%).
12	Specialisation Diploma Laboratory	K_W06, K_U04, K_U05, K_U07, K_U28, K_U29	General requirements for the diploma thesis and basic guidelines. Techniques for writing a scientific paper. Formulating the thesis topic. Methods for searching literature and data sources. Writing the introduction. Defining research objectives, formulating research problems and conclusions. Processing and analysis of research results. Preparing presentations and presenting work results. Presentation of thesis chapters.	Semester 1 credit: preparation of a literature review and chapter outline for a paper on a given topic. Semester 2 credit: preparation of a preliminary overview of the whole paper, presentation of the paper to the group.

* To be completed by the Quality Assurance and Accreditation Office (DJiOK)