Załącznik nr 2 do Uchwały Senatu nr 7/2026

STUDY PROGRAMME

Effective from the academic year: 2026/2027

FIELD OF STUDY: DATA ENGINEERING

1. **ISCED code: 0719**
2. **Mode of study: Full-time, First-cycle degree**
3. **Number of semesters: 7**
4. **Professional title awarded to graduates: Engineer**
5. **Education profile: General academic**
6. **Field of science: Natural science**
7. **Scientific discipline:**
   - ✓ **leading discipline: PHYSICAL SCIENCES – 107 ECTS (51% of ECTS credits)**
   - ✓ **supplementary disciplines: COMPUTER SCIENCE – 74 ECTS (35% of ECTS credits), MATHEMATICAL SCIENCE– 29 ECTS (14% of ECTS credits)**
8. **Total number of ECTS credits required for graduation: 210**
   1) number of ECTS credits that a student must obtain through courses conducted with the direct participation of academic teachers or other instructors: **127 – full-time studies**
   2) number of ECTS credits that a student must obtain through courses related to scientific research conducted in the discipline or disciplines to which the field of study is assigned, exceeding 50% of the total number of ECTS credits): **113,**
   3) number of ECTS credits that a student obtains by completing elective courses (at least 30% of the total number of ECTS credits): **70**
   4) number of ECTS credits that a student must obtain through courses in the field of humanities or social sciences, not less than 5 ECTS credits – in the case of fields of study assigned to disciplines within domains other than humanities or social sciences, respectively: **5**
9. **Total number of contact hours: 5316 – full-time studies** – including:
   - number of contact hours conducted with the direct participation of academic teachers or other instructors: **3236 – full-time studies**
   - number of contact hours conducted using distance learning methods and techniques: **0 – full-time studies**
10. **Educational concept and objectives** (including a description of the graduate profile):

The concept of the engineering field of study Data Engineering, based on the discipline of physical sciences, assumes the application of methods and tools from the fields of computer science, artificial intelligence and machine learning to the collection, management, processing and analysis of large data sets generated in physical experiments. This approach enables efficient extraction of information and supports research decision-making, taking into account physical and technical aspects. The field of study is interdisciplinary in nature and combines the physical foundations of the description of phenomena with advanced information processing skills.

The **Data Engineering** field of study integrates solid foundations in physics, computer science and mathematics with modern methods of data engineering, large-scale data analysis and scientific computing. The educational content is closely related to the research activity conducted at the Faculty of Exact and Natural Sciences of UJK, including, inter alia, experiments carried out at the European Organization for Nuclear Research (CERN), the application of machine learning algorithms to galaxy classification, large-scale and optimized analysis of images and data originating from global astronomical projects, data analysis in the fields of medical sciences and health sciences, research on the applications of artificial intelligence and machine learning in the analysis of spatial data, as well as the use of modern methods of data analysis and processing, including statistical methods, for the interpretation of experimental and simulation results. These contents are coherently linked with the development of engineering competences.

The educational concept is based on the development of practical skills in data analysis and programming, the use of tools applied in scientific research and modern technologies, as well as on preparing students for teamwork and independent solving of complex computational problems.

The objective of education in first-cycle engineering studies in the **Data Engineering** field of study is to educate a graduate who possesses:
- knowledge in the fields of physics, computer science and mathematics,
- knowledge and skills in the analysis of large experimental and simulation data sets in physics and related sciences, using modern technologies and information technology tools,
- skills in the design and implementation of algorithms for processing experimental data,
- skills in the visualization, interpretation and modelling of natural phenomena based on data,
- the ability to practically use platforms and computer software applied in data engineering, machine learning, deep learning and artificial intelligence,
- the ability to program in languages used in data engineering (in particular the Python language) and to use appropriate libraries of specialized software,
- knowledge and skills in the field of data security and computer systems security,
- engineering competences including, inter alia, the analysis of problems arising from physical research and measurement processes, the formulation of data models and computational models and the assessment of their quality, the design and optimization of solutions and processes, taking into account

the limitations of measurement equipment, the integration of data from various sources, the application of methods of filtering, calibration and validation of measurement data, the management of databases containing experimental and simulation data, scalable processing of large data sets, the creation of data visualizations and computational results, the preparation of technical reports and project documentation, as well as responsibility for the correctness of data analyses and the interpretation of results, and awareness of the impact of data analysis technologies on the development of science and society,

- the ability to use the acquired knowledge and qualifications in professional work,
- the ability to work in interdisciplinary teams and to solve professional problems,
- the ability to use scientific literature and computer-based databases,
- the ability to use a foreign language at a proficiency level of at least B2, including specialist terminology in the field of data engineering.

A graduate of the **Data Engineering** field of study is able to combine skills in physics, computer science and mathematics and apply them in natural sciences, engineering and industrial applications. The graduate is a specialist who integrates physical knowledge with advanced competences in data analysis and processing. They are capable of effectively working with large data sets, creating computational models, and supporting data-driven decision-making processes.

The graduate is prepared for work in research laboratories and scientific institutes, for employment in technological, energy, industrial and information technology enterprises, as well as for participation in research and development projects. The graduate also possesses competences enabling the continuation of education at second-cycle and third-cycle studies. The graduate is characterized by analytical thinking, problem-solving skills, and readiness to adapt in a dynamically changing technological environment.

Graduates of the **Data Engineering** field of study may find employment in institutions specializing in data acquisition, analysis and processing, in units dealing with data security, as well as in private and public enterprises in positions requiring advanced competences in information analysis and the development of solutions supporting the strategies and decision-making processes of employers. They may undertake employment, inter alia, in statistical offices, banks, enterprises, public institutions, higher education institutions and research laboratories. Graduates of the Data Engineering field of study are offered by the Institute of Physics of UJK the opportunity to continue their education in three-semester second-cycle studies in the field of Physics.

11. **Learning outcomes:**

Explanation of symbols:
ID1A — learning outcomes for the Data Engineering field of study, first-cycle engineering studies, general academic profile,
W — category of knowledge, U — category of skills, K — category of social competences,
01, 02, 03 and subsequent — learning outcome number.

Symbols of learning outcomes for the field of study	**Upon graduation, the graduate:**	**Reference of learning outcomes to:** the universal descriptors for the relevant level of the Polish Qualifications Framework (Act on the Integrated Qualifications System)	**Reference of learning outcomes to:** the second-cycle descriptors of learning outcomes for qualifications at levels 6–7 of the Polish Qualifications Framework (Regulation of the Ministry of Science and Higher Education)	**Reference of learning outcomes to:** the second-cycle descriptors of learning outcomes for qualifications at levels 6–7 of the Polish Qualifications Framework enabling the attainment of engineering competences (Regulation of the Ministry of Science and Higher Education)
in terms of **KNOWLEDGE:**				
ID1A_W01	has advanced knowledge and understanding of elements of higher mathematics, including mathematical analysis, logic, linear algebra and discrete mathematics	P6U_W	P6S_WG	
ID1A_W02	has advanced knowledge and understanding of elements of probability theory, stochastic processes and mathematical statistics, as well as fundamental methods of inference and statistical modelling	P6U_W	P6S_WG	
ID1A_W03	has advanced knowledge and understanding of terminology, symbolism, concepts and physical laws appropriate to the exact and technical sciences	P6U_W	P6S_WG	

ID1A_W04	has advanced knowledge and understanding of physical phenomena and processes, as well as their applications in science and technology	P6U_W	P6S_WG P6S_WK	P6S_WG
ID1A_W05	is familiar with scientific instruments and measurement equipment used in physics and its applications for the collection, management and processing of large data sets	P6U_W	P6S_WG	P6S_WG P6S_WI
ID1A_W06	has knowledge and understanding of selected issues in the fields of electrical engineering, electronics and metrology that are essential for technical and engineering applications	P6U_W	P6S_WG	P6S_WG P6S_WI
ID1A_W07	has knowledge and understanding of selected issues in the field of information technologies used in data analysis, including the principles of computer systems security and data protection	P6U_W	P6S_WG	P6S_WG
ID1A_W08	is familiar with selected methods, techniques and programming tools used in solving engineering problems in the field of data analysis	P6U_W	P6S_WK	
ID1A_W09	is familiar with selected numerical methods and data analysis algorithms	P6U_W	P6S_WG	
ID1A_W10	has advanced knowledge and understanding of issues in the field of databases, including their structure, organization and application in data processing, including in Big Data environments, as well as the principles of data security and information protection in database systems	P6U_W	P6S_WG	P6S_WG
ID1A_W11	possesses structured and advanced interdisciplinary knowledge in the fields of physical sciences, computer science and mathematics, enabling the modelling, analysis and interpretation of data originating from large data sets generated by physical experiments as well as from technical processes and simulations	P6U_W	P6S_WG	P6S_WI
ID1A_W12	has knowledge of specialized issues in the field of the studied programme, including issues related to artificial intelligence as well as machine learning and deep learning methods, and their applications in data analysis and processing	P6U_W	P6S_WG	
ID1A_W13	has knowledge of selected issues from disciplines related to physics, computer science and mathematics, associated with data analysis, process modelling and the interpretation of results in an interdisciplinary context	P6U_W	P6S_WG	
ID1A_W14	has knowledge and understanding of the principles of using professional literature, databases and other sources of information in order to obtain necessary information and assess its reliability	P6U_W	P6S_WK	
ID1A_W15	has knowledge and understanding of concepts and issues in the fields of social sciences, economics and other non-technical determinants of engineering activity	P6U_W	P6S_WK	P6S_WK
ID1A_W16	has knowledge and understanding of the principles of industrial property protection, copyright law, patent information, as well as occupational health and safety	P6U_W	P6S_WG P6S_WK	P6S_WK
ID1A_W17	has knowledge and understanding of the general principles of creating and developing forms of individual entrepreneurship, as well as of designing their own development path in the field of data	P6U_W	P6S_WG P6S_WK	P6S_WK

	engineering			
ID1A_W18	has knowledge and understanding of ethical, social and legal challenges related to the collection, analysis and use of data, including the application of artificial intelligence algorithms	P6U_W	P6S_WK	P6S_WK

in terms of **SKILLS:**

ID1A_U01	is able to use the apparatus of higher mathematics to formulate and solve typical problems in the field of data analysis	P6U_U	P6S_UW	P6S_UW
ID1A_U02	is able to analyse and explain observed physical phenomena and processes	P6U_U	P6S_UW	
ID1A_U03	is able to use basic physical instruments and measurement equipment to plan and perform physical measurements, including the assessment of the reliability of the determined physical quantities and statistical analysis of measurement results, working independently or in a team; and identifies measurement technique	P6U_U	P6S_UW	P6S_UW
ID1A_U04	is able to build a measurement system based on a provided schematic and perform measurements; design and construct an electrical and electronic circuit as well as a simple technical device; analyse the operation of typical technical solutions and assess them according to specified criteria	P6U_U	P6S_UW	P6S_UW
ID1A_U05	is able to interpret and explain relationships expressed in the form of formulas, tables, graphs and diagrams, and apply them to practical problems	P6U_U	P6S_UW	P6S_UW
ID1A_U06	is able to use selected software and information technologies for the collection, retrieval, statistical analysis and visualization of data, as well as for text editing and presentation preparation, while observing the principles of computer systems security and data protection	P6U_U	P6S_UW	P6S_UW
ID1A_U07	is able to identify problems, including practical issues, that can be solved algorithmically; is able to develop and analyse an algorithm consistent with a given specification; and is able to use a selected high-level programming language as well as appropriate information technology tools in the form of computer software used in data engineering	P6U_U	P6S_UW P6S_UU	P6S_UW
ID1A_U08	is able to design, develop and manage database systems, including in Big Data environments, applying appropriate data structures and organization, as well as ensure data security and information protection in database systems	P6U_U	P6S_UW P6S_UU	P6S_UW
ID1A_U09	is able to integrate knowledge from the field of physical sciences, information technology tools and mathematical methods in order to analyse, model and forecast natural phenomena described by data	P6U_U	P6S_UW	P6S_UW
ID1A_U10	is able to analyse and solve problems, including complex and non-standard ones, related to the studied field, including in the area of analysis of large data sets from physical experiments, artificial intelligence, machine learning and deep learning, and to find solutions using acquired methods; and	P6U_U	P6S_UW	P6S_UW

	is able to perform tasks under conditions that are not fully predictable			
ID1A_U11	is able to plan and carry out basic scientific research in the field of analysis of experimental physical data and simulations using physical, information technology and mathematical tools, and to analyse their results	P6U_U	P6S_UW	P6S_UW
ID1A_U12	is able to use a foreign language at the B2 level of the Common European Framework of Reference for Languages, to the extent necessary to use basic professional literature and to communicate with specialists in the field of data engineering	P6U_U	P6S_UK	
ID1A_U13	is able to obtain information from professional literature, databases and other sources, integrate this information, interpret it and draw conclusions, formulate opinions, and critically evaluate information originating from unverified sources	P6U_U	P6S_UW P6S_UU	
ID1A_U14	is able to present current issues related to data engineering, including in the form of a short presentation in Polish and English, using various sources of knowledge and multimedia tools	P6U_U	P6S_UW P6S_UK	
ID1A_U15	is able to properly organize their own work and cooperate and work in a team, taking responsibility for their own tasks as well as for jointly performed tasks	P6U_U	P6S_UO	
ID1A_U16	is able to communicate with the environment, participate in debate, and present and evaluate different opinions and viewpoints	P6U_U	P6S_UO	
ID1A_U17	is able to prepare written works (including the diploma thesis) and projects concerning specific issues related to the studied field, using basic theoretical concepts and methods of data engineering, based on various sources of information	P6U_U	P6S_UW P6S_UK	P6S_UW
ID1A_U18	is able to identify problems related to the professional activity and the need to develop professional and personal competences, and is capable of carrying out the process of self-education and lifelong learning	P6U_U	P6S_UU	

in terms of **SOCIAL COMPETENCES:**

ID1A_K01	is able to determine priorities serving the accomplishment of tasks, plan their work, systematically familiarize themselves with scientific and popular science content originating from various sources, and critically assess the received content	P6U_K	P6S_KK	
ID1A_K02	is able to responsibly perform their professional role, comply with the principles of professional ethics and respect the law, including copyright law, and require the same from others, as well as care for the achievements and traditions of the profession	P6U_K	P6S_KR	
ID1A_K03	is able to fulfil social obligations and co-organize outreach and popularization activities for the social environment in the field of selected achievements of science and technology and their practical applications	P6U_K	P6S_KO	

ID1A_K04	is able to formulate and justify opinions concerning professional issues, and to be innovative and entrepreneurial	P6U_K	P6S_KK P6S_KO	
ID1A_K05	is able to recognize the importance of knowledge in problem-solving, including with consideration of socio-economic consequences, and to seek the opinions of experts	P6U_K	P6S_KK P6S_KO	

12. **Courses with assigned ECTS credits, learning outcomes and course content:**

Courses (classes)	Number of ECTS credits	Course content	Reference to the learning outcomes for the field of study
GENERAL EDUCATION COURSES (CLASSES): (19 ECTS credits)			
1. Foreign language course	9	Lexical content: elements of specialist vocabulary related to the field of study, the University, the subject of study, types of studies, the significance of education; other content includes everyday life, culture, social phenomena and well-known problems of the contemporary world, and is consistent with the syllabus of the textbooks in use for the B2 level. Grammatical content: consistent with the syllabus of textbooks intended for the B2 level and in accordance with the requirements of the Common European Framework of Reference for Languages of the Council of Europe. Language functions: consistent with the syllabus of textbooks for the B2 level and enabling students to communicate fluently in a foreign language, actively participate in discussions and debates, engage in polemics and develop compromise solutions, express emotions and opinions, argue and formulate their point of view both orally and in written form.	ID1A_W14 ID1A_U12 ID1A_U13 ID1A_U14 ID1A_U17
2. Information and Communication Technologies	1	Fundamentals of information and communication technologies. Computer use. Word processing and spreadsheets. Databases. Managerial and presentation graphics. Web browsing and electronic communication. Scientific and technical applications.	ID1A_W07 ID1A_U06 ID1A_K02
3. Protection of Intellectual Property and Copyright Law	1	The concept and origins of the protection of industrial property and copyright. Copyright and related rights. Moral and economic copyright	ID1A_W16 ID1A_K02

			rights. Protection of databases. Inventions (patents), utility models and industrial designs – protection of inventions. Trademarks and geographical indications – the concept and types of trademarks. Combating unfair competition. Agreements concerning copyright. Industrial property protection.	
4.	Entrepreneurship	1	The concept and types of entrepreneurship. The entrepreneur – definition, behaviours and classifications. Internal and external determinants of the development of entrepreneurship. Entrepreneurship and the enterprise. Conditions for establishing and conducting one's own business activity. Areas of entrepreneurship – family entrepreneurship, women's entrepreneurship, academic entrepreneurship, social entrepreneurship and intellectual entrepreneurship.	ID1A_W15 ID1A_W17 ID1A_K04 ID1A_K05
5.	Course/Courses (Classes) covering content in the humanities or social sciences	5	Culture of language: normative linguistics, language norm, error, types of language errors, usage (usus), codification of the norm, shaping language habits; changes in language and their causes, borrowings and their role, foreign influences on the Polish language, language improvement, legal aspects of the protection of the Polish language, attitudes towards language and norms, issues of orthographic and punctuation correctness; aesthetics of language, brutalization of language, vulgarization and devulgarization, linguistic etiquette, etiquette in linguistic communication; ethics of language in communication, linguistic manipulation and persuasion. Philosophy of nature: introduction to the philosophy of nature. The essence of philosophy. Basic orientations in ontology and epistemology. Philosophy and its branches. Developmental stages of the philosophy of nature. Philosophy of nature in the early period of ancient philosophy. The idealistic view of nature. Main philosophical currents in different epochs. The concept of nature from a philosophical perspective. Philosophical issues of contemporary science. Ecophilosophy as a practical philosophy of nature. The essence and origin of life and philosophical interpretations of scientific theories. The impact of the scientific and information revolutions on our view of nature and humanity. Contemporary philosophers of	ID1A_W15 ID1A_U18 ID1A_K03 ID1A_W15 ID1A_U18 ID1A_K03

			nature and their views. The significance of the philosophy of nature for humans in the 21st century.	
6.	Course/Courses (Classes) supporting students in the learning process	2	Self-learning techniques: the idea of formal and non-formal education in Poland and worldwide. Lifelong education. Psychological foundations of mental work efficiency. E-learning as a technology for information acquisition. Techniques of information perception and reception. Education as a form of cognitive therapy. Effective learning as a method of career planning. Howard Gardner's theory of multiple intelligences and the process of self-learning/learning. Educational capabilities of the brain (left and right hemispheres). Neurodidactics. Activating methods of mental work. Memory techniques. Mnemonics. Sociotechnical techniques. Forgetting strategies. The book in academic studies – text analysis. Methods and tools used in natural sciences self-learning. Proactive and reactive planning. Goal setting. Principles of effective memorization. Supporting career development – methods and tools. The essence of memory in the self-learning process. Methods of self-management in time. Developing time management skills. Preparation of an individual self-development plan. Social communication: the essence of the communication process; verbal and non-verbal communication; types of communication processes, levels of communication, selected models of interpersonal communication, interpersonal communication and its components in everyday practice, communication in small groups and organizations; communication versus persuasion and manipulation, political propaganda; communication and gender; public speaking, globalization in social communication.	ID1A_W15 ID1A_U18 ID1A_K03 ID1A_W15 ID1A_U18 ID1A_K03

FUNDAMENTAL/FIELD-SPECIFIC COURSES (CLASSES): (132 ECTS credits)

1.	Basics of Mathematics	4	Elements of mathematical logic: propositional calculus, propositional functions, laws of the calculus of quantifiers. Set algebra. Basic properties of real-valued functions of a real variable. Sequences and series of numbers. Differential calculus of functions of one variable. Matrix calculus.	ID1A_W01 ID1A_U01 ID1A_U05 ID1A_U13 ID1A_K01

2.	Data Engeenering in Physics	3	Physical quantities, units and the SI system. Fundamentals of physical measurements. Data collection and recording. Introduction to data analysis. Basics of data processing and visualization. Applications of physics and data in an engineering context.	ID1A_W03 ID1A_W04 ID1A_U02 ID1A_U03 ID1A_K01
3.	Physics 1	5	Position vector, coordinate system, reference frame. Velocity of a material point as the time derivative of position and motion with constant velocity. Acceleration and motion with constant acceleration. Distance as the time integral of velocity. Galilean transformation and the law of velocity addition. The three laws of dynamics. Motion under the action of a constant force. Static and kinetic friction. Kinetic and potential energy, the principle of conservation of mechanical energy. Momentum and the principle of conservation of momentum. Inertial and non-inertial frames and inertial forces. The law of universal gravitation, work in a gravitational field and potential energy. Motion of an Earth satellite, first and second cosmic velocity. Microscopic versus macroscopic description of a many-body system, Avogadro's number, the mole. Atoms, molecules, gases, liquids and solids. Basic thermodynamic quantities: volume, pressure, work. Temperature and the zeroth law of thermodynamics. The ideal gas equation and the absolute temperature scale. The equipartition theorem and the energy of an ideal gas. The first law of thermodynamics. Processes: isothermal, isobaric, isochoric, adiabatic. Heat capacity, specific heat. The van der Waals gas as a model of a real gas. Phase diagram of water, critical point, superheated liquid, supercooled gas. Reversible and irreversible processes. The second law of thermodynamics. The Carnot engine and its efficiency.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U11 ID1A_K01
4.	Programmer's Environment	2	Linux shell (bash) commands: basic operations on files and directories, operations on file attributes. Data stream redirections and pipelines. Operations on text files, regular expressions (searching, sorting). Bash shell scripting: script invocation arguments, variables, environment variables. Bash shell scripting: arithmetic operations and logical operations. Bash shell scripting: user interaction, conditional statements, loops and functions. LaTeX typesetting system: document preparation,	ID1A_W08 ID1A_U07 ID1A_U10 ID1A_U15 ID1A_K03 ID1A_K04

			typesetting of mathematical expressions. LaTeX typesetting system: creating presentations – the beamer class. Editing a C source file, execution of a source file, compilation (gcc). Compilation automation – the make utility.	
5.	Introduction to Programming	5	Fundamentals of programming and algorithmics: algorithm, program, programming language, the role of programming in data engineering, program structure in Python. Data types and operators: basic data types, arithmetic and logical operators, data input and output. Control statements: conditional statements, loops, nested statements, examples of iterative algorithms. Exception handling. Functions and modularity: function definition, parameters and return values, variable scope, code organization. Data structures: lists, tuples, sets, dictionaries, operations on collections, iteration over data structures. Fundamentals of object-oriented programming: object-oriented paradigm, class and object, attributes and methods, constructor, use of objects in data processing.	ID1A_W08 ID1A_U07 ID1A_U10 ID1A_K03 ID1A_K04 ID1A_K05
6.	Fundamentals of Electrical Engineering and Electronics	6	Fundamentals of electricity and magnetism. Direct current and sinusoidally varying current. Basic electrical engineering devices. Fundamental laws of electrical circuits. Basic methods of electrical circuit analysis. Analysis of circuits with RLC elements. Resonance in electrical circuits. Electric current in solids. Band model. Physical fundamentals of the operation of semiconductor devices. PN junction. Basic semiconductor components, models of semiconductor devices. Integrated circuits. Basic electronic circuits, amplifiers, oscillators. Basic digital circuits, flip-flops and counters, semiconductor memories, microprocessor systems.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_W06 ID1A_U03 ID1A_U04 ID1A_K01
7.	Basic Physics Laboratory	2	Experiments demonstrating fundamental physical laws and phenomena in the fields of kinematics, dynamics, mechanical waves, thermodynamics, structure of matter, electricity and magnetism, and electromagnetic waves.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U03 ID1A_K01
8.	Mathematics	5	Integral calculus of functions of one variable. Differential calculus of functions of several variables. Elements of optimization. Multiple integrals. Introduction to differential equations. Properties of a binary	ID1A_W01 ID1A_U01 ID1A_U05

			operation; definitions of a semigroup, group, ring and field. The field of complex numbers. Vector spaces: definition of a vector space, examples, subspaces, sum and direct sum of subspaces. Systems of vectors, basis and dimension of a vector space. Linear mappings, kernel and image, matrix representation of a mapping. Matrices: operations on matrices, the space of matrices. Row and column operations on matrices. The concept of the rank and trace of a matrix. Systems of linear equations, the Kronecker–Capelli theorem, the Gaussian elimination method. Matrix determinant. Cramer's rule. Singular and non-singular matrices. Inverse matrix. Characteristic polynomial of a matrix, eigenvalues and eigenvectors of an endomorphism. Diagonal form of a matrix, canonical form of a matrix. Jordan matrix and Jordan basis. Inner product. LU decomposition, QR decomposition and other matrix decompositions. Singular value decomposition (SVD).	ID1A_K01
9.	Physics 2	5	Electric charge. Coulomb's law. The principle of superposition. Electrostatic field and potential. Field lines. Gauss's law. Electrostatics in material media. Capacitors. Electric current. Ohm's law. Direct current circuits. Magnetic field. The Biot–Savart law and Ampère's law. Interaction of a magnetic field with an electric charge. Magnetic properties of matter. Electromagnetic induction. Faraday's law. Self-induction phenomena. Maxwell's equations and their physical interpretation. Electromagnetic waves: properties, spectrum, transmission of energy and information. Diffraction and interference of electromagnetic waves. Huygens' principle. Basic applications of electromagnetic waves in technology and information systems.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U11 ID1A_K01
10.	Physics 3	6	Limitations of classical physics and the emergence of modern physics. The importance of modern physics in technology; the role of physics in the development of electronics and digital systems, the discrete nature of energy and its practical significance, quantum phenomena as a source of new technological possibilities, properties of conductors, semiconductors and insulators, the influence of material structure on its electrical behavior, the operating principles of simple semiconductor devices, the significance of doping and material layers, semiconductor	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U11 ID1A_K01

			components as fundamental elements of digital systems, limitations resulting from miniaturization, physical foundations of signal measurement and detection, the role of sensors in information systems, physics and the development of data processing technologies, and the importance of physics in modern information technologies.	
11.	Measuring Techniques	4	Basic concepts of electrical metrology and the most important measurement methods. Fundamentals of error theory and measurement uncertainty. Standards of electrical units (electrical standards based on the definition of a physical phenomenon, material standards of electrical quantities, reference multimeters and calibrators). Electromechanical measuring instruments (magnetoelectric and electromagnetic meters, electrodynamic wattmeters, induction meters). Recording instruments (oscilloscopes). Balanced and unbalanced bridge circuits. Compensation and comparison methods. Measurement signals and their processing. Conditioning of resistance, capacitance and inductance. AC/DC conversion. Voltage-to-frequency conversion. Signal amplification (amplifiers). Feedback in measurement transducers. Quality of analog signal processing. Analog-to-digital conversion. Introduction to digital signal processing.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_W06 ID1A_U03 ID1A_U04 ID1A_U05 ID1A_K01
12.	Introduction to Algorithms	2	Basic concepts of algorithmics: algorithm, flowchart, activity network, iteration, recursion. Simple iterative and recursive algorithms: finding the minimum value, factorial computation, Horner's scheme. Divide and conquer method: Min–Max algorithm, binary search algorithm. Searching and sorting methods: linear search, interpolation search, bubble sort, selection sort. Data structures: lists, stacks, graphs and trees. Dynamic programming: computation of Fibonacci numbers, Floyd's algorithm. Greedy programming and optimization problems: knapsack problem, minimum spanning tree. Backtracking algorithms: the N-queens problem. Algorithm analysis: input data size, dominant operations, time and memory complexity, algorithm class.	ID1A_W01 ID1A_W09 ID1A_U01 ID1A_U05 ID1A_U07 ID1A_K01 ID1A_K03 ID1A_K04
13.	Probability Theory and Statistics	6	Probability space. Axiomatic definition of probability. Properties of probability. Conditional probability. The theorem of total probability. Bayes' formula. Independence of random events. One-dimensional	ID1A_W02 ID1A_U01 ID1A_U05

			random variables and their probability distributions. Cumulative distribution function. Functions of a random variable. Parameters of a random variable distribution. Examples of discrete and continuous distributions. Multidimensional random variables. Limit theorems. Basic statistical concepts. Classification of statistical characteristics. Design of a statistical study. Grouping and presentation of statistical data. Numerical characteristics of population structure: measures of location, dispersion, asymmetry and concentration. Random sample, distributions of sample statistics. The concept of an estimator and properties of "good" estimators. Basic methods of constructing estimators. Point and interval estimation of population parameters. The problem of minimum sample size. Statistical hypothesis testing.	ID1A_U06 ID1A_U15 ID1A_K01
14.	Cloud Technologies in Data Engineering	3	Cloud service models: IaaS, PaaS, SaaS, FaaS; public vs private services; CapEx vs OpEx – cloud economics. Overview of major providers: AWS, GCP, Azure, Oracle Cloud. Fundamentals of cloud security: IAM, VPC, encryption. Fundamentals of AWS (Amazon Web Services) services for data engineering. Fundamentals of GCP (Google Cloud Platform) services for data engineering. Fundamentals of Azure (Microsoft Cloud Platform) services for data engineering. Modern cloud services, including, inter alia, Snowflake, Databricks, Apache ecosystem, Delta Lake, GitHub, GitLab, and others. Cloud data streaming architectures. Sample projects using cloud technologies.	ID1A_W07 ID1A_W08 ID1A_W10 ID1A_W12 ID1A_U06 ID1A_U07 ID1A_U10 ID1A_U11 ID1A_U15 ID1A_K01
15.	Discrete Mathematics	4	Recursion. Definitions and examples: the Towers of Hanoi problem, the Fibonacci sequence, the gambler's ruin. Methods for solving recurrences using characteristic equations and generating functions. Divide-and-conquer recurrences, the Master Theorem. Combinatorial counting techniques. Dirichlet's pigeonhole principle, the principle of inclusion and exclusion, examples of advanced counting problems. Graphs. Definitions of basic concepts; adjacency and incidence matrices; incidence lists; Eulerian, Hamiltonian, connected and planar graphs; graph traversal; weighted graphs. Graph algorithms: finding a minimum spanning tree, finding the shortest path. Steiner tree, Small World networks, vertex and edge coloring of graphs and their applications, graph coloring algorithms,	ID1A_W01 ID1A_W09 ID1A_U01 ID1A_U07 ID1A_K01

			labeled trees with a distinguished root, representation of arithmetic expressions, Polish notation. Networks. Event networks, flows in networks, the max-flow min-cut theorem.	
16.	Organization of Computer Systems	5	Overview of basic data representation standards. Boolean arithmetic. Design of combinational circuits. Methods for optimizing combinational circuits. Design of sequential circuits. Analysis of data flow using timing diagrams. Operation of basic digital blocks (adders, registers, memory). Processor architectures: single-cycle, multi-cycle and pipelined architectures. Fundamentals of the MIPS architecture. Basics of machine language. Microarchitecture (single-cycle, multi-cycle and pipelined architecture). Types of memory (cache, virtual memory).	ID1A_W07 ID1A_W12 ID1A_U05 ID1A_U07 ID1A_K03
17.	Numerical Methods in Physical Applications	3	Introduction to numerical errors. Finite and iterative methods for solving equations and systems of linear and nonlinear equations. Nonparametric least-squares approximation of physical measurement data, algebraic and orthogonal polynomials. Methods for function minimization. Fitting parameters of a mathematical physical model to experimental data. Numerical integration of ordinary and partial differential equations. Numerical solution of models of selected physical phenomena. Application of the Monte Carlo method in modelling physical processes.	ID1A_W01 ID1A_W02 ID1A_W09 ID1A_U01 ID1A_U02 ID1A_U05 ID1A_U07 ID1A_U10 ID1A_U11 ID1A_U15 ID1A_K03 ID1A_K04
18.	Physics Laboratory	8	As part of the Laboratory, students perform exercises from various fields of physics (mechanics, heat, electricity, magnetism, optics). Students are required to master the scope of material specified in the questions for each exercise, which are included in the instructions for individual exercises. The subject matter of the exercises, their sequence and method of execution, as well as the requirements concerning reports and the elaboration of results, are specified in the documentation and the programme of the Physics Laboratory.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U03 ID1A_U15
19.	Stochastic Processes in Physics	4	Definition and examples of processes in discrete and continuous systems. Functions of random variables. Fourier and Laplace transforms.	ID1A_W02 ID1A_W11

			Characteristic function. Correlation and power spectrum, harmonic analysis of stochastic processes. Stationary processes. Markov and non-Markov processes. The Chapman–Kolmogorov equation. Models of stochastic processes in physical sciences. Birth-and-death processes. Models of radioactive decay processes. The Malthus–Verhulst population growth model. Models of Brownian motion. Diffusion processes and diffusion with chemical reactions. Stable probability distributions, heavy-tailed distributions. Models of anomalous diffusion: subdiffusion and superdiffusion. Definition and properties of fractional-order derivatives. Applications of differential equations with fractional derivatives to the description of selected physical processes, in particular anomalous diffusion processes, and the stochastic interpretation of these equations.	ID1A_W13 ID1A_W14 ID1A_U01 ID1A_U05 ID1A_U09 ID1A_U10 ID1A_U14 ID1A_U15 ID1A_K01 ID1A_K03
20.	Statistics in Physical Applications	5	Statistical hypothesis testing. Errors that may occur in experimental physics when testing hypotheses. Power of a statistical test. Hypothesis testing concerning population parameters (Student's t-tests, one-way analysis of variance). Non-parametric tests. Goodness-of-fit tests. Correlation analysis and an introduction to linear regression. Forms of representation of multivariate data. Descriptive analysis of multivariate data. Measures of dependence. Principal component analysis and its geometric interpretation. Multivariate normal distribution. Selected tests. Multivariate analysis of variance. Analysis of qualitative data. Selected issues in cluster analysis and object classification. Survival analysis. Reliability analysis in engineering. Applications of Monte Carlo simulations in experimental physics. Case studies from physics and engineering – data analysis in a computational environment.	ID1A_W02 ID1A_W03 ID1A_W04 ID1A_W11 ID1A_U01 ID1A_U05 ID1A_U06 ID1A_U09 ID1A_U15 ID1A_U16 ID1A_K01
21.	Astronomical Data Engineering	5	Fundamentals of astronomical data processing and analysis. Introduction to types of astronomical objects contained in databases and the physical parameters characterizing them. Sources of astronomical data: observations and their numerical reduction, computer simulations. Data quality assessment, elements of observational statistics. Automation of data analysis. Data archiving: the FITS standard, file compression. Astronomical catalogues and database systems, data management. Information retrieval in open databases. Multidimensional visualization	ID1A_W02 ID1A_W03 ID1A_W04 ID1A_W07 ID1A_W09 ID1A_W10 ID1A_W11 ID1A_U01

			of astronomical data.	ID1A_U02 ID1A_U05 ID1A_U06 ID1A_U08 ID1A_U09 ID1A_U10 ID1A_U11 ID1A_U13 ID1A_K01 ID1A_K05
22.	Basics of Neural Networks	5	Neuron model, sigmoid function, perceptron, neural network, biological analogy. Associative and heteroassociative memory. Supervised learning, backpropagation, unsupervised learning. Examples of applications in data processing. Hopfield and Kohonen networks. Computer modelling of simple neural networks.	ID1A_W07 ID1A_W08 ID1A_W18 ID1A_U07 ID1A_U10 ID1A_K01 ID1A_K02
23.	Computer Networks	4	Basic concepts and principles underlying computer networks. LAN networks based on Ethernet technology. The IP protocol. Transport layer: UDP and TCP protocols. DNS. Wireless networks. Dynamic routing protocols. Application layer: FTP and HTTP protocols. Elements of cryptography. Fundamentals of security: attacks and tunnels. Peer-to-peer networks, NAT and firewalls.	ID1A_W07 ID1A_W12 ID1A_U10 ID1A_K01
24.	Databases	4	Types and models of contemporary databases. Database structure, integrity and normalization. The relational database model: data organization, criteria of relationality, rules and relationships. Basic elements and concepts of the relational data model: tables and their design, types of tables, primary key, foreign key, data duplication, atomic information. Fundamentals of the Structured Query Language (SQL): data types, creation, modification and deletion of tables, populating tables with data, queries, subqueries, joins, aggregate functions, transactions, integrity constraints. Database management systems and their functions.	ID1A_W08 ID1A_W10 ID1A_W14 ID1A_U06 ID1A_U13 ID1A_U15 ID1A_K03 ID1A_K04
25.	Data Visualization Techniques	4	Introduction to issues related to graphical data presentation on the World	ID1A_W06

			Wide Web. Introduction to the D3 library. Fundamentals of the technologies used (HTML, DOM, CSS, JavaScript, SVG). Preparation of the working environment (WAMP server, terminal with a Python interpreter, references to the D3 library). Data preparation (creating elements, data binding). Graphical data presentation (drawing using div elements, drawing using SVG elements, preparing various types of charts). Updates, transitions and motion (ordinal scales, event listener functions, updating scaling functions, data binding using keys). Interactivity (binding event listener functions, grouping SVG elements, tooltips). Chart layouts (including pie, stacked and force-directed layouts). Geographic maps (GeoJSON, paths, projections, choropleth maps). Exporting (bitmap maps, PDF files, SVG files).	ID1A_W08 ID1A_W09 ID1A_U05 ID1A_U06 ID1A_K02
26.	Analysis of Experimental Data	4	Data from large detector systems: methods of data acquisition, recording, formatting, online selection, quality control and data visualization. Data management, descriptive statistics, estimation and verification of statistical hypotheses. Formats and structures of large physical data sets. Data analysis: methods of data reading, offline selection, graphical preparation and substantive interpretation of results. Correction of results for detector effects, acceptance effects and unwanted physical effects. Use of simulation data from models based on the Monte Carlo method. Analysis of exemplary data sets obtained in research experiments and model data.	ID1A_W02 ID1A_W03 ID1A_W04 D1A_W05 ID1A_W07 ID1A_W08 ID1A_W09 ID1A_W10 ID1A_W11 ID1A_W12 ID1A_U01 ID1A_U02 ID1A_U03 ID1A_U05 ID1A_U06 ID1A_U09 ID1A_U10 ID1A_U11 ID1A_U12 ID1A_U13 ID1A_K01

				ID1A_K04 ID1A_K05
27.	Experimental Data Sources	5	Sources of experimental data in physics and engineering sciences. Types of data generated by measurement systems. Structure and formats of data from modern research instruments. Calibration, correction and validation of measurement data. Introduction to analytical techniques in the context of data: spectral data (EDXRF, WDXRF, TXRF techniques), diffraction data (XRPD, SCXRD, GIXRD), scattering data (SAXS, GISAXS), imaging and spatial data (μXRF, μXRD, μCT). Data from spectroscopic and time-resolved methods. EPR and NMR as sources of high-resolution spectral data. Practical aspects of data processing: data analysis tools and automation of information analysis from raw experimental data. Integration of experimental data with statistical analysis.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_W07 ID1A_W08 ID1A_W09 ID1A_W10 ID1A_W11 ID1A_W12 ID1A_U01 ID1A_U02 ID1A_U03 ID1A_U05 ID1A_U06 ID1A_U09 ID1A_U10 ID1A_U11 ID1A_U12 ID1A_U13 ID1A_K01 ID1A_K04 ID1A_K05
28.	Group Project	4	Selection of the project topic, assessment of project workload, and division of tasks within the team. Selection of technologies necessary for task implementation. Preparation of an initial vision and concept of the designed system. User interface design. System implementation: selection of methods and sequence of tasks. Preparation of technical documentation. Testing: test plans and test documentation. Implementation of corrections and improvements.	ID1A_W08 ID1A_W11 ID1A_W13 ID1A_W14 ID1A_W18 ID1A_U15 ID1A_U09 ID1A_U10 ID1A_U13

				ID1A_U14 ID1A_U15 ID1A_K01
29.	Computer Systems Security	4	Introduction to security issues, fundamentals of local Unix system security. Issues related to data storage and data protection. Security in TCP/IP networks, elements of network security in Unix-based systems. Optimal configuration of network services, firewall systems, intrusion detection systems. Introduction to cryptology, the most important cryptographic methods and tools.	ID1A_W07 ID1A_W08 ID1A_W12 ID1A_W13 ID1A_W16 ID1A_U10 ID1A_K02
30.	Big Data Systems and Distributed Processing	3	Introduction to Big Data and distributed systems architecture. MapReduce model, HDFS, Apache Hadoop, Apache Spark. NoSQL databases, Data Lakes, cloud-based processing. Stream data processing – Apache Kafka, Apache Flink. Scalability, reliability and data security. Configuration of Hadoop/Spark environments, operations on large data sets. Data analysis using Spark SQL and PySpark. Integration with NoSQL databases (MongoDB, Cassandra). Stream data processing – Kafka Streams. Containerization and deployment of distributed systems using Docker and Kubernetes.	ID1A_W07 ID1A_W08 ID1A_W10 ID1A_W12 ID1A_W18 ID1A_U06 ID1A_U07 ID1A_U08 ID1A_U10 ID1A_U11 ID1A_U15 ID1A_U16 ID1A_K01 ID1A_K03 ID1A_K04 ID1A_K05
31.	Data Quality Management and Data Governance		Introduction to data quality management – concepts and standards (ISO 8000, DAMA-DMBOK). Data lifecycle and the importance of data quality in decision-making processes. Data Governance frameworks and structures – policies, roles and responsibilities. Methods for measuring data quality – completeness, accuracy, consistency, timeliness. Tools for data quality management and their integration with data warehouses. Data profiling and data cleansing. Implementation of the Data Quality Assessment	ID1A_W07 ID1A_W08 ID1A_W10 ID1A_W12 ID1A_W18 ID1A_U06 ID1A_U07

			process in Talend/Informatica environments. Use of the Great Expectations tool for data validation. Team project: development of a Data Governance implementation plan for an organization. Reporting and visualization of data quality metrics.	ID1A_U08 ID1A_U10 ID1A_U11 ID1A_U15 ID1A_U16 ID1A_K01 ID1A_K03 ID1A_K04 ID1A_K05

ELECTIVE COURSES (CLASSES): (53 ECTS credits)

1.	Courses related to the preparation and submission of the diploma thesis	17	**Diploma Seminar:** Ability to familiarize oneself with the presented topic of the diploma thesis. Formulation of the research problem and identification of a method for its solution. Collection of source materials, their analysis and selection, including the selection of scientific literature related to the diploma thesis topic. Analysis of a selected scientific article related to the diploma thesis topic. Preparation of an oral presentation – a communication. A paper – its objectives and practical implementation. Formulating theses, discussion and their defense. Preparation of the assumptions of the diploma thesis and discussion of formal and editorial principles of its preparation (thesis structure, formatting, style, basic principles of citation and bibliography preparation). Analysis of research and project progress in students' practical works. Preparation of thesis documentation and presentation of the obtained results. **Diploma Laboratory**: work plan, outline. Selection of literature, referencing, plagiarism. Individual consultations monitoring the progress of work	ID1A_W11 ID1A_W12 ID1A_W13 ID1A_W14 ID1A_W18 ID1A_U09 ID1A_U10 ID1A_U11 ID1A_U12 ID1A_U13 ID1A_U14 ID1A_U15 ID1A_U16 ID1A_U17 ID1A_U18 ID1A_K01 ID1A_K02 ID1A_K04 ID1A_K05 ID1A_W11 ID1A_W12

			(simulations, programmed applications). Collection and processing of materials, writing of the thesis.	ID1A_W13 ID1A_W14 ID1A_W18 ID1A_U09 ID1A_U10 ID1A_U11 ID1A_U12 ID1A_U13 ID1A_U14 ID1A_U15 ID1A_U16 ID1A_U17 ID1A_U18 ID1A_K01 ID1A_K02 ID1A_K04 ID1A_K05
2.	Elective courses (classes) expanding students' interests	36	**1. Database Systems:** basic concepts related to databases and database systems. Database models and functions of a database management system. Methods of accessing a database. The relational database model. Advanced mechanisms for handling relational databases. Fundamentals of database management scripting languages (e.g. PHP). Management of an Internet-based database using forms and scripts written in a selected language (e.g. PHP). **2. Generative Artificial Intelligence in Data Engineering:** history of generative AI: from Markov chains to GPT. Definition and scope of Generative Artificial Intelligence (GenAI). Generative vs. discriminative models. Fundamental paradigms: likelihood-based, implicit density, energy-based. Breakthrough GenAI technologies: GANs (2014), Transformers (2017), GPT-3 (2020), ChatGPT (2022). The landscape of contemporary GenAI: OpenAI, Anthropic, Google, Meta, Mistral, xAI. Business and social applications. Ethical aspects and responsible use	ID1A_W10 ID1A_W12 ID1A_U06 ID1A_U15 ID1A_K01 ID1A_K03 ID1A_K04 ID1A_W11 ID1A_W12 ID1A_W13 ID1A_U09 ID1A_U10 ID1A_K03 ID1A_K05

			of GenAI. Mathematical foundations of GenAI. Autoencoders. The concept of GANs (Generative Adversarial Networks). Diffusion models. Image generation models. “Text-to-image” models. Transformers. Large Language Models (LLMs) (GPT, Claude, Gemini, Llama, Grok, Bielik, etc.). Training and fine-tuning of LLMs. Advanced methods and techniques of prompt engineering. RAG (Retrieval-Augmented Generation) methods. AI agents. GenAI metrics. Human–AI collaboration. **3. Machine Learning:** preliminary data analysis and preprocessing. Supervised learning. Decision trees. Artificial neural networks. Classification and regression problems. Unsupervised learning. Cluster analysis. Reinforcement learning. Control. Optimization. Performance evaluation. **4. Deep Learning:** advanced data analysis and processing. Advanced supervised learning. Deep neural networks. Detection and segmentation problems. Advanced unsupervised learning. Deep reinforcement learning. Transfer learning. Multimodal data (images, audio, time series). **5. Data Exploration Algorithms:** introduction to data mining. Types of data mining tasks. Data clustering and segmentation. Evaluation of the quality of classification and regression models, testing, cross-validation. Bayesian classifier. Classification trees. Association rule mining. Semantic analysis, natural language processing.	ID1A_W07 ID1A_W08 ID1A_W11 ID1A_W12 ID1A_U07 ID1A_U10 ID1A_U11 ID1A_K03 ID1A_W07 ID1A_W08 ID1A_W11 ID1A_W12 ID1A_U07 ID1A_U10 ID1A_U11 ID1A_K03 ID1A_W07 ID1A_W09 ID1A_U06 ID1A_U07 ID1A_U10 ID1A_K02 ID1A_K03 ID1A_K05

			6. Computer-Aided Design: introduction to the FreeCAD software package. Overview of the interface and document structure. Creation and editing of solids, extrusion of solids. Creation of two-dimensional sketches based on constraints. Adding, subtracting and combining solids. Creation of three-dimensional models. Modelling of textual objects in drawings. Dimensioning. Views and cross-sections of drawings. Preparation for printing. Lighting and rendering. Scripts and macros. 3D printing.	ID1A_W07 ID1A_U06 ID1A_K02
			7. Artificial Intelligence Methods in Data Analysis: basic concepts and definitions of AI. History and evolution of artificial intelligence methods. Data preparation for AI algorithms. Basic machine learning methods. Deep learning in data analysis. Evolutionary and genetic algorithms. Natural language processing (NLP). Speech analysis techniques. Computer vision. Small language models. Large Language Models (LLMs). Prompt engineering. Retrieval-Augmented Generation (RAG) systems. Model fine-tuning and adaptation. Multimodal AI models. AI agents and autonomous systems. Graph neural networks. Interpretation and evaluation of modern AI models. Ethics, security and responsible AI.	ID1A_W07 ID1A_W08 ID1A_W11 ID1A_W12 ID1A_W18 ID1A_U06 ID1A_U09 ID1A_U10 ID1A_K01 ID1A_K02 ID1A_K04 ID1A_K05
			8. C# Programming: introduction to the .NET Framework using Microsoft Visual C#. Methods of program debugging. C# language syntax. Access modifiers for class members, information hiding. Namespaces. Initialization of class instances. Accessing attributes. Operators and operator overloading. Class inheritance. Multiple inheritance. Polymorphism. Exceptions and exception handling. GUI development using WinForms and WPF.	ID1A_W13 ID1A_U07 ID1A_U10 ID1A_U15 ID1A_K02 ID1A_K03 ID1A_K04
			9. .NET Technologies: .NET Framework libraries and classes. Data access methods in ADO.NET technology. Overview of the LINQ concept, principles of object serialization, introduction to XML and XAML technologies, and principles of building web applications using ASP.NET technology. The Micro Framework platform and its applications. SPOT technology.	ID1A_W13 ID1A_U07 ID1A_U10 ID1A_U15 ID1A_K03

				ID1A_K04
			10. Image Processing: perception, acquisition and representation of digital images. Geometric transformations. Point-wise and arithmetic transformations. Digital filtering in the spatial domain and in the frequency domain. Morphological transformations. Colors and methods of their representation. Color image processing. Lossless and lossy image compression methods.	ID1A_W13 ID1A_U07 ID1A_U10 ID1A_U15 ID1A_K03 ID1A_K04
			11. Project Management in Data Engineering: specificity of data engineering projects versus traditional IT projects. Data project lifecycle: from concept to deployment. Roles in data projects: data engineer, data analyst, data scientist, product owner. Stakeholders in data projects: business, IT, compliance. Key challenges: data quality, integrations, scaling. Success metrics for data projects. Portfolio, programme and project – differences and management. Traditional project management methodologies – Waterfall and PRINCE2. Agile in data projects. Scrum for data engineering teams. Kanban and Lean in data engineering. DevOps and DataOps. Risk management in data projects. Tools and platforms for data-driven project management.	ID1A_W07 ID1A_W08 ID1A_W12 ID1A_W13 ID1A_W16 ID1A_U06 ID1A_U10 ID1A_U14 ID1A_U15 ID1A_U16 ID1A_U18 ID1A_K01 ID1A_K02
			12. Virtualization of Server Environments: introduction to virtualization. Virtualization tools. Architecture of virtualization systems. Network communication in virtual environments. Mechanisms for access to disk storage. Creation and maintenance of virtual machines. Distributed environments. High-availability systems. Network traffic load balancing. Performing backups and restoring virtualized systems.	ID1A_W07 ID1A_W08 ID1A_W12 ID1A_U06 ID1A_U07 ID1A_U10 ID1A_U15 ID1A_K01 ID1A_K03 ID1A_K04

			13. Web Applications: basic components of the World Wide Web architecture. HTML 5.0. Cascading Style Sheets (CSS). JavaScript. Bootstrap. PHP and MySQL.	ID1A_W07 ID1A_W08 ID1A_W09 ID1A_U05 ID1A_U06 ID1A_U12 ID1A_U18 ID1A_K01 ID1A_K02 ID1A_K04
			14. Mathematical Methods in Physics: elements of vector calculus. Orthogonal and orthonormal bases. Linear, Hermitian and unitary operators. Fourier transform and Laplace transform. Solving differential equations with applications in physics. Partial differential equations. Integrals of functions of several variables. Line integrals. Field operators.	ID1A_W01 ID1A_W11 ID1A_W13 ID1A_W14 ID1A_U01 ID1A_U09 ID1A_U10 ID1A_U13 ID1A_K01 ID1A_K03
			15. Structure of Matter: hierarchical structure of matter. Elementary particles and atomic nuclei. Atoms and quantum phenomena. Molecules and chemical bonding. Condensed matter.	ID1A_W03 ID1A_W04 ID1A_U01 ID1A_U02 ID1A_U05 ID1A_U13 ID1A_U17 ID1A_K01 ID1A_K03 ID1A_K04

			16. Classical Physics: mechanics of a system of N material points. Newtonian formalism. Mechanics of systems with constraints. Lagrangian formalism. Canonical formalism. Deterministic chaos.	ID1A_W03 ID1A_W04 ID1A_U02 ID1A_K01
			17. Metrology: historical development. Practical and civilizational significance of metrology. Formal aspects of measurements of physical quantities. Measurements of basic physical quantities. Interpretation of measurement results. Units and standards of physical quantities. Traceability and consistency of measurement results. Quantum metrology. Measurements of mechanical, electromagnetic and thermodynamic quantities. Flow measurements. Measurements of ionizing radiation. Standards of physical quantities. Fundamental physical constants. Formal aspects and organization of the system of metrological units. Directions of development of contemporary metrology.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_W12 ID1A_W12 ID1A_W14 ID1A_U02 ID1A_U03 ID1A_U05 ID1A_U10 ID1A_U13 ID1A_K01
			18. Physics Laboratory II: as part of the second Physics Laboratory, students perform advanced exercises in experimental physics from various fields of physics, including optics, molecular physics, atomic physics and thermodynamics.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U03 ID1A_U15
			19. Physics Laboratory III: experiments using advanced research and measurement equipment in the fields of X-ray fluorescence analysis, computed tomography, X-ray diffraction and reflectometry, X-ray photoelectron spectroscopy, investigation of surface topography of materials, and diffusive transport of substances.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U03 ID1A_U15
			20. Measurement Instrumentation Programming: examples of applications cooperating with measurement devices. The LabVIEW	ID1A_W07 ID1A_W08

			environment. Methods of graphical programming and the syntax of the G language.	ID1A_W12 ID1A_W13 ID1A_U06 ID1A_U07 ID1A_U10 ID1A_K01
			21. Nanophysics: classification and properties of nanosystems. Methods of fabrication of nanosystems and design of their properties. Nanoparticles in nature and their role. Methods for investigating the properties of thin films as well as quantum wires and quantum dots. Selected applications of nanostructures in semiconductor physics. Use of lithography in modern technologies. Nanotechnologies in microelectronics and optoelectronics.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_W12 ID1A_W13 ID1A_U02 ID1A_U03 ID1A_U13 ID1A_K01 ID1A_K04
			22. Nanomaterials and their Applications: basic properties of nanomaterials. Nanomaterials in nature. Methods of nanomaterial fabrication. Methods for investigating nanosystems. Nanomaterials and their limitations. Selected nanotechnologies in engineering (microelectronics, optoelectronics). The role and application of nanomaterials in biology and medicine. Selected research equipment used in nanomaterials studies. Nanomaterials engineering.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_W12 ID1A_W13 ID1A_U02 ID1A_U03 ID1A_U13 ID1A_K01 ID1A_K04
			23. Fundamentals of Quantum Physics: wave–particle duality. General characteristics of atomic spectra, blackbody radiation, the Bohr model of the hydrogen atom, quantization of angular momentum, spin, fermions and bosons, the Pauli exclusion principle, the de Broglie hypothesis. The Schrödinger equation. The wave function and its physical interpretation.	ID1A_W01 ID1A_W04 ID1A_U01 ID1A_U02 ID1A_K01

			Heisenberg uncertainty relations. Quantization as an eigenvalue problem. Probability amplitudes. The state of a system in classical mechanics and quantum mechanics. Examples of applications of the Schrödinger equation.	ID1A_K03
			24. Introduction to Nuclear Physics: brief history of the development of nuclear physics. The atomic nucleus (isotopes, isobars, isotones, isomers). Properties of stable nuclei and basic parameters of atomic nuclei. Nuclear forces. Binding energy of atomic nuclei, mass defect. Electric charge of atomic nuclei, spin and magnetic moment of nucleons, hyperfine interactions. Models of nuclear structure. Radioactive decay (radioactive series). Radiation spectra. Nuclear reactions. Nuclear transformations. Natural and artificial sources of radiation.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U03 ID1A_U05 ID1A_K01 ID1A_K04 ID1A_K05
			25. Astronomy: elements of spherical astronomy. Structure of the Solar System. Stars: fundamentals of heliophysics, spectral types of stars, their internal structure and sources of energy, stellar evolution. Interstellar matter. Galaxies: morphological classification, structure and evolution. Large-scale structure of the Universe. Evolution of the Universe, cosmological models.	ID1A_W01 ID1A_W03 ID1A_W04 ID1A_W09 ID1A_U01 ID1A_U02 ID1A_K01 ID1A_K05
			26. Econophysics: basic concepts of economics. Functioning of financial markets. Elements of game theory. Stochastic processes. Option pricing. Market risk. Portfolio theory. Linear and chaotic dynamics.	ID1A_W07 ID1A_W10 ID1A_W12 ID1A_W13 ID1A_U06 ID1A_U07 ID1A_U10 ID1A_U11 ID1A_U15 ID1A_U16

				ID1A_K01 ID1A_K03
			27. Quantum Computers: complex numbers and complex matrices. Description of a single qubit. Operations on a single qubit. Classical and quantum random walks. Two qubits – introduction and description. The no-cloning theorem, Bell states. Three qubits and more. Classical and quantum cryptography. Grover's search algorithm. Greenberger–Horne–Zeilinger (GHZ) state. Quantum annealing.	ID1A_W03 ID1A_W04 ID1A_W07 ID1A_U02 ID1A_U07 ID1A_K01
			28. Scientific Research Methodology: science and scientific knowledge; fundamentals of scientific work and conducting research. Characteristics of research methods, techniques and tools. Formulation of research objectives and hypotheses. Publication of scientific research. Databases of scientific articles. Analysis of selected scientific articles. Construction of a research instrument. Types of variables in scientific models and scales for measuring variables; types of relationships between variables. Examples of interdisciplinary research. Scientific research in medical physics. Application of scientific research in problem-solving.	ID1A_W13 ID1A_W14 ID1A_U11 ID1A_U12 ID1A_U13 ID1A_U16 ID1A_U17 ID1A_K01
			29. Green Transformation: environmental threats as barriers to human development. Socio-economic consequences of climate change. Green transformation as a tool for sustainable development. Selected areas of green transformation in the economy (energy sector, water management, waste management). Green transformation policy. From a linear economy to a circular economy. Green transformation of cities.	ID1A_W13 ID1A_U13 ID1A_W18 ID1A_K01 ID1A_K03
			30. Nuclear Energy: first experiments and discoveries related to nuclear fission. Technical possibilities of nuclear fission. Organizational structure of international and national bodies responsible for radiological protection supervision. Development of research reactors. Nuclear techniques in medicine and other branches of industry. Mobile and propulsion reactors. Nuclear power sources in satellites. The first nuclear power plants. Importance of nuclear energy. Power reactors. Legal aspects related to	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U02 ID1A_U03 ID1A_K01 ID1A_K04

			the operation of nuclear facilities. Exposure to ionizing radiation in nuclear facilities and environmental monitoring. Hazards during accidents, emergency plans and examples of accidents.	ID1A_K05
			31. History of Science: origins of science and the formation of fundamental concepts. Major achievements of antiquity. The decline of the Middle Ages, the rise of the Renaissance and geographical discoveries. The birth and development of universities. The Copernican revolution, Kepler, Galileo, Descartes. Empiricism and rationalism. Newton and the formation of the scientific method. The relationship between science and technology. Darwin and evolutionism. Triumphs of nineteenth-century science. The birth of modern physics. Cosmology. The atomic bomb and the conquest of space. Computers and the Internet. Genetic engineering and cloning.	ID1A_W13 ID1A_U13 ID1A_K03
			32. Biostatistics: introduction to biostatistics. Types of statistical data in the context of medical applications. Distributions and descriptive statistics of medical data and data visualization. Types of statistical inference. Point and interval estimation of population parameters commonly used in medical applications. Statistical hypothesis testing (medical data). Non-parametric methods. Goodness-of-fit tests. Tests of independence. Regression and correlation methods. Analysis of variance. Planning of medical studies. Randomization of studies. Cohort studies. Cross-sectional studies. Statistical evaluation of diagnostic tests. Determination and interpretation of ROC curves. Logistic regression. Survival analysis.	ID1A_W02 ID1A_W07 ID1A_W08 ID1A_U01 ID1A_U05 ID1A_U06 ID1A_U13 ID1A_K01
			33. Fundamentals of Financial Mathematics: time value of money. Accumulation and discounting. Interest rate intensity. Cash flows. Installment repayment of debt, cost of credit, foreign currency loans, credit risk. Basic debt instruments: bills of exchange, certificates, treasury bills, bonds. Valuation of debt and financial instruments. Investment profitability.	ID1A_W01 ID1A_W11 ID1A_W13 ID1A_W14 ID1A_U01 ID1A_U09 ID1A_U13 ID1A_U14

				ID1A_K01 ID1A_K03 ID1A_K04 ID1A_K05
			34. Econometrics: linear econometric models with one and multiple variables. Model goodness of fit. The method of least squares and other estimation methods. Classical model assumptions and their impact on the properties of estimators. Tests concerning the deterministic and stochastic structure of the model. Statistical methods for selecting variables for the model. Nonlinear models. Dummy variables. Lagged variables. Prediction based on an econometric model. Ex post and ex ante forecast errors. Multiequation models. Identification and estimation of model equations.	ID1A_W01 ID1A_W11 ID1A_W13 ID1A_W14 ID1A_U01 ID1A_U09 ID1A_U13 ID1A_U14 ID1A_K01 ID1A_K03 ID1A_K04 ID1A_K05
			35. Mathematical Economics: equilibrium analysis. Mathematical theory of demand. Commodity space. Preference relations. Utility function. Indifference curves. Demand function. Theory of production. Production spaces. Production efficiency. Competitive and market equilibrium, and Pareto optimum. Growth analysis. Stability of competitive equilibrium. Long-run growth equilibrium.	ID1A_W01 ID1A_W11 ID1A_W13 ID1A_W14 ID1A_U01 ID1A_U09 ID1A_U13 ID1A_U14 ID1A_K01 ID1A_K03 ID1A_K04 ID1A_K05
			36. Fundamentals of Cryptography: symmetric-key cryptography. The S-DES system. Public-key cryptography. Diffie–Hellman key exchange. RSA and ElGamal systems. Knapsack cryptosystem. RSA digital signature.	ID1A_W02 ID1A_W13 ID1A_W14

			Elliptic curves. Key exchange using elliptic curves. Digital signatures based on elliptic curves. Integer factorization methods. Pseudorandom number generation.	ID1A_U01 ID1A_U10 ID1A_U13 ID1A_K01 ID1A_K03 ID1A_K04 ID1A_K05
			37. Game Theory: conflict of interests in economic activity and its game-theoretic approach. Games in strategic (normal) form. Pure and mixed strategies. Strategy dominance. Equilibrium strategies and their significance. Nash equilibrium. Two-player games. Zero-sum games. Non-zero-sum games. Evolutionary games. Evolutionary scenarios. Evolutionarily stable strategy. Cooperative games. Shapley value. Negotiations in games.	ID1A_W01 ID1A_W02 ID1A_U05 ID1A_U10 ID1A_K01

INTERNSHIPS (duration, rules and form): (6 ECTS credits)

INTERNSHIPS (duration, rules and form): 120 hours The internship is carried out in various workplaces (e.g. enterprises and IT companies, laboratories, research centres) that enable the full implementation of its detailed programme.	6	The detailed curriculum content of the internship is determined by the supervisor appointed at the institution where the student undertakes the internship, who oversees the student's work. The objectives of the internship are: - development of skills in applying acquired theoretical knowledge in practice, - gaining insight into the functioning of a specific institution, - becoming familiar with the nature of work in various positions and in different sectors substantively related to the field of study, - gaining knowledge of practical issues related to work in positions consistent with the chosen specialization, - recognizing one's own opportunities in the labour market and establishing professional contacts.	ID1A_W12–W18 ID1A_U06-U07 ID1A_U10 ID1A_U12 ID1A_U13 ID1A_U15 ID1A_U16 ID1A_U18 ID1A_K01–K05

total	**210**

Full-time students (applicable to first-cycle and long-cycle Master's degree programmes) **are required to complete physical education classes amounting to not less than 60 hours.**

Students are required to complete training on health and safety in education, with a duration of not less than 4 hours, taking into account the specific nature of education at the university and the type of technical equipment used in the educational process.

Students are required to complete pre-medical first aid classes with a duration of 5 hours (for teacher education programmes) or 4 hours (for other fields of study).

Students are required to complete library training with a duration of 2 hours.

No ECTS credits are assigned to these classes.

Additionally, international students enrolled in full-time first-cycle and long-cycle Master's degree programmes (excluding the English Division) are required to complete a Polish language course amounting to 4 ECTS credits.

13. **Methods for verifying and assessing learning outcomes achieved by the student throughout the entire course of study:**

Achievement of all learning outcomes defined for individual courses constitutes the implementation of the assumed educational concept of the programme and the attainment of programme learning outcomes. Verification and assessment of the learning outcomes achieved by the student throughout the entire cycle of education are carried out through:

- **continuous assessment tasks** – completed by the student during the course of studies, such as quizzes, tests, coursework assignments, papers, presentations, laboratory reports, and projects, in accordance with instructions prepared by the course instructor; all additional forms require separate instructions,
- **written and oral examinations** – the form of the examination is determined by the course instructor and specified in the course syllabus; examination questions should not go beyond the content included in the course syllabus implemented as part of the course,
- **pass/fail assessments and graded pass assessments** – the course instructor defines the assessment criteria, specifies its components, and provides a descriptive justification of the grade awarded to the student,
- **the degree-awarding process** – assessment of the engineering thesis by the thesis supervisor and reviewer, and passing the diploma examination,
- **student internships** – learning outcomes achieved as part of internships complement the educational concept; verification of outcomes is conducted in accordance with the internship regulations applicable to individual programmes,

- **achievements of student research groups** – feedback obtained through external reviews (scientific publications, conference presentations, Rector's and Minister's scholarships awarded),
- **graduate tracking studies** – through obtaining feedback on acquired knowledge, skills and social competences and their usefulness in the labour market,
- **employer feedback surveys** – employers' evaluation of study programmes, including the intended learning outcomes and the methods of their verification.

The forms and methods of teaching, as well as the assessment criteria and their components, are specified in the course (class) syllabus.
All forms of verification of student achievements obtained within a given semester are recorded in the student's periodic achievement records.