Załącznik nr 2 do uchwały Senatu nr 77/2025

THE STUDY PROGRAMME

Valid from the academic year: **2025/2026**

1. FIELD OF STUDY: **DATA ENGINEERING**
2. ISCED CODE: **0719**
3. FORM OF STUDY: **FULL-TIME, FIRST-CYCLE DEGREE**
4. NUMBER OF SEMESTERS: **7**
5. DEGREE TO BE AWARDED: **ENGINEER**
6. PROFILE OF EDUCATION: **GENERAL ACADEMIC**
7. FIELD OF SCIENCE: **NATURAL SCIENCES**
8. DISCIPLINES OF SCIENCE:
   leading discipline: **PHYSICAL SCIENCES (55% ECTS**)
   complementary disciplines**: MATHEMATICAL SCIENCES (25% ECTS), COMPUTER SCIENCE (20% ECTS)**
9. **The total number of ECTS credits required for graduation: 210**
   1) the number of ECTS credits a student must obtain through classes conducted with the direct participation of academic teachers or other instructors: **127**
   2) the number of ECTS credits a student must obtain through courses related to scientific research conducted in the discipline or disciplines to which the field of study is assigned, in an amount exceeding 50% of the total number of ECTS credits: **113**
   3) the number of ECTS credits a student obtains by completing elective courses (at least 30% of the total number of ECTS credits): **81**
   4) the number of ECTS credits a student must obtain through courses in the field of Humanities or Social Sciences: **5**
10. **Total number of class hours: 5316 – including hours of classes conducted with the direct participation of academic teachers or other instructors: 3236**
11. **Educational concept and objectives (including graduate profile)**:
    The objective of the first-cycle engineering programme is to educate graduates who:
    - possess knowledge and skills in data analysis using the latest technologies and IT tools;
    - are able to practically use platforms and software dedicated to data engineering, deep learning, and artificial intelligence;
    - demonstrate basic programming skills in Python and are capable of using appropriate specialist software libraries;
    - have knowledge of general issues within the disciplines covered by the programme;
    - can apply acquired knowledge and skills in professional practice;
    - are capable of solving professional problems and working effectively in teams;
    - can use scientific literature and computer-based information databases;
    - are able to communicate in a foreign language at B2 level and use specialised terminology in the field of data engineering.

    The overarching practical goal of the programme is to prepare specialists with hands-on skills in data processing and analysis using computer tools based on cutting-edge information technologies (Big Data, Data Mining, Artificial Intelligence, Machine Learning). The programme educates professionals in the use of specialised software as well as analytical methods and tools for solving problems related to the analysis of real-world data. Graduates are also equipped with the ability to visualise and interpret obtained results. They acquire knowledge and skills in the areas of data security and computer systems security.

    Graduates of the Data Engineering programme will be qualified to work in institutions specialising in data acquisition and processing, as well as in data security. They may be employed in both private and public enterprises in positions requiring the ability to analyse information and develop solutions that support employers' strategies and decision-making processes. Graduates can pursue careers in statistical offices, banks, businesses, enterprises, universities, and research laboratories.

Graduates of the Data Engineering programme are offered the opportunity to continue their education in a three-semester second-cycle (Master's) programme in Physics at the Institute of Physics of Jan Kochanowski University.

12. LEARNING OUTCOMES:

Explanation of symbols:

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

Learning outcome codes for the field of study	Upon graduation, the graduate:	Reference of learning outcomes to:		
	LEARNING OUTCOMES	the universal characteristics of the Polish Qualifications Framework (PQF), as defined in the Act on IQS	second-degree characteristics of learning outcomes for qualifications at levels 6–7 of the Polish Qualifications Framework (Regulation of the Ministry of Science and Higher Education)	second-degree characteristics of learning outcomes for qualifications at levels 6–7 of the Polish Qualifications Framework that enable the acquisition of engineering competences (Regulation of the Ministry of Science and Higher Education)
	in the area 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 the elements of probability calculus, stochastic processes, and mathematical statistics, including the fundamental methods of inference and statistical modeling	P6U_W	P6S_WG	
ID1A_W03	has advanced knowledge and understanding of terminology, symbolism, concepts, and physical laws relevant to the natural 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	has knowledge and understanding of selected topics in electrical engineering, electronics, and measurement techniques relevant to technical and engineering applications	P6U_W	P6S_WG	P6S_WG
ID1A_W06	has knowledge and understanding of selected issues in information technologies used in data analysis	P6U_W	P6S_WG	P6S_WG

ID1A_W07	has knowledge of selected methods, techniques, and programming tools used in solving engineering tasks related to data analysis	P6U_W	P6S_WK	
ID1A_W08	has knowledge of selected numerical methods and data analysis algorithms	P6U_W	P6S_WG	
ID1A_W09	has advanced knowledge and understanding of database-related issues, including their structure, organization, and use in data processing	P6U_W	P6S_WG	P6S_WG
ID1A_W10	has knowledge of specialised topics within the field of study	P6U_W	P6S_WG	
ID1A_W11	has knowledge of selected topics from related disciplines associated with the field of study	P6U_W	P6S_WG	
ID1A_W12	has knowledge and understanding of the principles of using professional literature, databases, and other sources of information to acquire necessary data and assess its reliability	P6U_W	P6S_WK	
ID1A_W13	has knowledge and understanding of concepts and issues in the fields of social sciences, economics, and other non-technical factors influencing engineering activities	P6U_W	P6S_WK	P6S_WK
ID1A_W14	has knowledge and understanding of the principles of industrial property protection, copyright law, patent information, and occupational health and safety	P6U_W	P6S_WG P6S_WK	P6S_WK
ID1A_W15	has knowledge and understanding of the general principles of establishing and developing individual entrepreneurial initiatives, as well as designing a personal development path in the field of data engineering	P6U_W	P6S_WG P6S_WK	P6S_WK
ID1A_W16	has knowledge and understanding of the 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 the area of **SKILLS**, is able to:			
ID1A_U01	use higher mathematics to formulate and solve typical problems in the field of data analysis	P6U_U	P6S_UW	P6S_UW
ID1A_U02	analyse and explain observed physical phenomena and processes	P6U_U	P6S_UW	
ID1A_U03	use basic instruments and physical apparatus to plan and carry out physical measurements, assess the reliability of the determined physical quantities, and perform statistical analysis of the results, working independently or in a team; identifies measurement techniques	P6U_U	P6S_UW	P6S_UW
ID1A_U04	construct a measurement system based on a given diagram and perform measurements; is able to design and build electrical and electronic circuits as well as simple technical devices; is able to carry out a preliminary economic assessment of proposed solutions	P6U_U	P6S_UW	P6S_UW
ID1A_U05	interpret and explain relationships presented in the form of formulas, tables, charts, and diagrams, and apply them to practical problems	P6U_U	P6S_UW	P6S_UW
ID1A_U06	selected software and IT technologies for data collection, retrieval, statistical analysis, and visualisation, as well as for text editing and presentation preparation	P6U_U	P6S_UW	P6S_UW
ID1A_U07	identify problems, including practical ones, that can be solved algorithmically; is able to design and analyse an algorithm in accordance with the specification; is proficient in using a selected high-level programming language and appropriate IT tools, including software relevant to data engineering	P6U_U	P6S_UW P6S_UU	P6S_UW
ID1A_U08	analyse and solve problems — including complex and non-standard ones — related to the field of study, and to find solutions using learned methods; is able to carry out tasks in partially unpredictable conditions	P6U_U	P6S_UW	P6S_UW
ID1A_U09	plan and carry out basic scientific research within their field of study and analyse the results	P6U_U	P6S_UW	P6S_UW
ID1A_U10	use a foreign language at B2 level of the Common European Framework of Reference for Languages (CEFR), sufficient to read basic professional literature and communicate with specialists in the field of data engineering	P6U_U	P6S_UK	
ID1A_U11	obtain information from professional literature, databases, and other sources; integrate and interpret this information; draw conclusions, formulate opinions, and critically assess information from unverified sources	P6U_U	P6S_UW P6S_UU	
ID1A_U12	present current issues related to data engineering, including in the form of a short presentation in Polish	P6U_U	P6S_UW	P6S_UW

	and English, using various sources of knowledge and multimedia tools		P6S_UK	
ID1A_U13	effectively organise their own work and collaborate within a team, taking responsibility for individual and group tasks; is able to communicate with the environment, participate in discussions, and present and evaluate different opinions and viewpoints	P6U_U	P6S_UO	P6S_UK
ID1A_U14	prepare written papers (including a diploma thesis) and projects on specific issues related to the field of study, using basic theoretical concepts and data engineering methods based on various sources of information	P6U_U	P6S_UW P6S_UK	P6S_UW
ID1A_U15	identify problems related to professional practice and the need to improve professional and personal competences; is able to engage in self-directed learning and lifelong education	P6U_U	P6S_UU	
	In the area of **SOCIAL COMPETENCES**, is prepared to:			
ID1A_K01	set priorities for task completion, plan work, and systematically engage with scientific and popular science content from various sources, with a critical assessment of the received information	P6U_K	P6S_KK	
ID1A_K02	perform professional duties responsibly, observe professional ethics and legal regulations, including copyright law, expect the same from others, and respect the achievements and traditions of the profession	P6U_K	P6S_KR	
ID1A_K03	fulfil social responsibilities and co-organise outreach activities for the benefit of the community, concerning selected achievements in science and technology and their practical applications	P6U_K	P6S_KO	
ID1A_K04	formulate and justify opinions on professional matters, demonstrate innovation and entrepreneurship, recognise the importance of knowledge in problem-solving — including consideration of socio-economic impacts — and seek expert opinions	P6U_K	P6S_KK P6S_KO	

13. LIST OF COURSES WITH ASSIGNED ECTS CREDITS, LEARNING OUTCOMES, AND COURSE CONTENT

Courses		Minimum number of ECTS credits	Course content	Reference to learning outcomes for the field of study
GENERAL EDUCATION COURSES:				
1.	Foreign language course	9	**Lexical content**: Elements of specialist vocabulary related to the field of study; university-related terms, study subjects, types of study programmes, the importance of education. Additional content includes topics related to everyday life, culture, social phenomena, and well-known contemporary global issues, in accordance with the syllabus of B2-level coursebooks. **Grammar content**: In accordance with the syllabus of coursebooks designed for the B2 level and the requirements of the Common European Framework of Reference for Languages (CEFR) of the Council of Europe. **Language functions**: In line with the syllabus of B2-level coursebooks, enabling students to communicate fluently in a foreign language, actively participate in discussions and debates, engage in argumentation and compromise-building, express emotions and opinions, as well as present and justify their point of view both orally and in writing.	ID1A_W12 ID1A_U10 ID1A_U11 ID1A_U12 ID1A_U14
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_W06 ID1A_U06 ID1A_K02

3.	Protection of Intellectual Property and Copyright Law	1	The concept and origins of industrial property protection and copyright law. Copyright and related rights. Moral and economic rights of the author. Database protection. Inventions (patents), utility models and industrial designs – protection of inventions. Trademarks and geographical indications – the concept and types of trademarks. Combating unfair competition. Agreements related to copyright. Protection of industrial property.	ID1A_W14 ID1A_K02
4.	Entrepreneurship	1	The concept and types of entrepreneurship. Entrepreneur – definition, behaviours, and classifications. Internal and external determinants of entrepreneurial development. Entrepreneurship and enterprise. Conditions for starting and running one's own business. Areas of entrepreneurship – family, female, academic, social, and intellectual entrepreneurship.	ID1A_W13 ID1A_W15 ID1A_K04
5.	Courses covering content in the humanities or social sciences	5	Culture of Language Philosophy of Nature Interpersonal Communication Cultural Texts in the Communication Space Copywriting	ID1A_W13 ID1A_U15 ID1A_K03
6.	Courses supporting students in the learning process	2	Self-Education Techniques Social Communication Methods Supporting the Learning Process (selected topics) Tutoring, Coaching, Motivational Dialogue (development of personal and social competences)	ID1A_W13 ID1A_U15 ID1A_K03
	Total general college courses	**19**		
			FUNDAMENTAL/FIELD-SPECIFIC COURSES	
1.	Basics of Mathematics	4	Elements of mathematical logic: propositional calculus, propositional functions, rules of quantifier calculus. Set algebra. Basic properties of real functions of a real variable. Sequences and numerical series. Differential calculus of functions of one variable. Matrix calculus.	ID1A_W01 ID1A_U01 ID1A_U05 ID1A_U11 ID1A_K01
2.	Data Engeenering in Physics	2	Physical quantities, units, SI system. Fundamentals of physical measurements. Data collection and recording. Introduction to data analysis. Basics of data processing and visualisation. Applications of physics and data in the context of engineering.	ID1A_W03 ID1A_W04 ID1A_U02 ID1A_U03 ID1A_K01
3.	Physics 1	5	Position vector, coordinate system, frame of reference. Velocity of a material point as the time derivative of position and motion with constant velocity. Acceleration and motion with constant acceleration. Displacement as the integral of velocity over time. Galilean transformation and the law of velocity addition. Newton’s three laws of motion. Motion under a constant force. Static and kinetic friction. Kinetic and potential energy, the principle of conservation of mechanical energy. Momentum and the principle of conservation	ID1A_W03 ID1A_W04 ID1A_U02 ID1A_U09 ID1A_K01

			of momentum. Inertial and non-inertial reference frames, inertial forces. Law of universal gravitation, work in a gravitational field and potential energy. Motion of an Earth satellite, first and second cosmic velocity. Microscopic vs. macroscopic description of a many-body system, Avogadro's number, mole. Atoms, molecules, gases, liquids, and solids. Basic thermodynamic quantities: volume, pressure, work. Temperature and the zeroth law of thermodynamics. Ideal gas equation and absolute temperature scale. Equipartition of energy and internal energy of an ideal gas. First law of thermodynamics. Thermodynamic processes: isothermal, isobaric, isochoric, adiabatic. Heat capacity, specific heat. 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. Second law of thermodynamics. Carnot engine and its efficiency.	
4.	Programmer's Environment	2	Linux shell commands (bash): basic file and directory operations, file attribute operations. Data stream redirection, pipelines. Text file operations, regular expressions (searching, sorting). Bash shell scripts: script arguments, variables, environment variables. Bash shell scripts: arithmetic and logical operations. Bash shell scripts: user interaction, conditional statements, loops, and functions. LaTeX typesetting system: document creation, typesetting mathematical expressions. LaTeX typesetting system: creating presentations – beamer class. Editing a C source file, executing a source file, compilation (gcc). Compilation automation – make utility.	ID1A_W07 ID1A_U07 ID1A_U08 ID1A_U13 ID1A_K03 ID1A_K04
5.	Introduction to Programming	5	Overview of fundamental programming paradigms. Python interpreter, running programs. Data types in Python (numbers, strings, lists, dictionaries, tuples, files), dynamic types. Python statements, if tests and syntax rules, while and for loops, iterations. Functions basics: coding, calling, polymorphism. Scopes. Arguments. Modules and packages, module coding basics.	ID1A_W07 ID1A_U07 ID1A_U08 ID1A_K03 ID1A_K04
6.	Fundamentals of Electrical Engineering and Electronics	6	Fundamentals of electricity and magnetism. Direct and sinusoidally alternating current. Basic electrical devices. Fundamental laws of electrical circuits. Basic methods of electrical circuit analysis. Analysis of RLC circuits. Resonance in electrical circuits. Electric current in solids. Band model. Physical principles of semiconductor devices. PN junction. Basic semiconductor components, semiconductor device models. Integrated circuits. Basic electronic circuits, amplifiers, generators. Basic digital circuits, flip-flops and counters, semiconductor memories, microprocessor systems.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_U03 ID1A_U04 ID1A_K01
7.	Basic Physics Laboratory	2	Experiments demonstrating fundamental laws and physical phenomena in the areas of kinematics, dynamics, mechanical waves, thermodynamics, structure of matter, electricity and magnetism, and electromagnetic waves.	ID1A_W03 ID1A_W04 ID1A_U02 ID1A_U03 ID1A_K01
8.	Mathematics 1	4	Integral calculus of functions of one variable. Differential calculus of functions of several variables. Elements of optimization. Multiple integrals. Introduction to differential equations.	ID1A_W01 ID1A_U01 ID1A_U05 ID1A_U08

				ID1A_K01
9.	Mathematics 2	4	Properties of binary operations; definitions of semigroup, group, ring, and field. The field of complex numbers. Vector spaces: definition, examples, subspaces, sum and direct sum of subspaces. Vector systems, basis and dimension of a vector space. Linear mappings, kernel and image, matrix of a linear mapping. Matrices: matrix operations, matrix space. Row and column operations on matrices. Concept of matrix rank and trace. Systems of linear equations, Kronecker–Capelli theorem, Gaussian elimination method. Determinants of matrices. Cramer's systems. 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 basis. Scalar product. LU decomposition, QR decomposition and other matrix factorizations. Singular Value Decomposition (SVD).	ID1A_W01 ID1A_U01 ID1A_U05 ID1A_U08 ID1A_K01
10.	Physics 2	5	Point charges, Coulomb's law, principle of superposition of fields. Electrostatic field and potential, field lines and equipotential surfaces. Gauss's law. Electrostatics in a medium. Steady electric current and Ohm's law. Magnetostatics. Biot–Savart and Ampère's laws. Magnetic properties of matter. Faraday's law of induction, electric generator and motor. Maxwell's four equations. Electromagnetic waves. Wave classification. Interference, diffraction, and reflection of waves. Huygens' principle. Light as a wave. Diffraction and polarization of light. Fundamentals of geometrical optics. Elements of the theory of relativity. Elements of quantum mechanics. Elementary particles and atomic nuclei. Atoms and molecules. Structure of macroscopic matter.	ID1A_W03 ID1A_W04 ID1A_U02 ID1A_U09 ID1A_K01
11.	Measuring Techniques	4	Basic concepts of electrical measurements, key measurement methods. Fundamentals of error theory and measurement uncertainty. Standards of electrical units (electrical standards based on physical phenomena, material standards of electrical quantities, reference multimeters and calibrators). Electromechanical measuring instruments (magnetoelectric and electromagnetic meters, electrodynamic wattmeters, induction energy 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_U03 ID1A_U04 ID1A_K01
12.	Introduction to Algorithms	4	Fundamental concepts of algorithmics: algorithm, flowchart, activity network, iteration, recursion, data structures. Basic iterative and recursive algorithms: finding the minimum value, calculating factorial, Horner's scheme. Divide and conquer method: Min-Max algorithm, binary search algorithm, Strassen's algorithm. Searching and sorting methods: linear, binary, and interpolation search; bubble sort, selection sort, merge sort, quicksort. Data structures: array, record, single- and double-linked lists (linear and circular), stacks, graphs, and trees. Dynamic programming: computing Fibonacci numbers, Floyd's algorithm. Greedy algorithms	ID1A_W01 ID1A_W08 ID1A_W09 ID1A_U01 ID1A_U05 ID1A_U07 ID1A_K01

			and optimization problems: knapsack problem, minimum spanning tree. Backtracking algorithms: N-queens problem, maze solving. Algorithm analysis: input size, dominant operations, time and memory complexity, sensitivity and algorithm class.	ID1A_K03 ID1A_K04
13.	Probability Theory	4	Probability space. Axiomatic definition of probability. Properties of probability. Conditional probability. Law of total probability. Bayes' theorem. Independence of random events. Univariate random variables and their probability distributions. Cumulative distribution function (CDF). Functions of a random variable. Distribution parameters of a random variable. Examples of discrete and continuous distributions. Multivariate random variables. Limit theorems.	ID1A_W02 ID1A_U01 ID1A_U06 ID1A_K01
14.	Object Oriented Programming	5	Overview of basic programming paradigms. Object-oriented programming environments. Concept of an object, simple examples of objects, analogy to real-world entities. Object-oriented domain modeling. Features of object-oriented programming. Object attributes – fields and methods. Access modifiers, information hiding. Namespaces. Initialization of class instances. Accessing attributes. Operators and operator overloading. Class inheritance, access to base class members, inheritance vs. class composition. Multiple inheritance. Polymorphism. Exceptions and exception handling. Iterators.	ID1A_W07 ID1A_U07 ID1A_U08 ID1A_U13 ID1A_K03 ID1A_K04
15.	Discrete Mathematics	4	Recursion. Definitions and examples: Towers of Hanoi problem, Fibonacci sequence, gambler's ruin. Methods for solving recurrences using characteristic equations and generating functions. Divide and conquer recurrences, master theorem. Combinatorial counting techniques. Pigeonhole principle, inclusion-exclusion principle, examples of advanced counting problems. Graphs. Definitions of basic concepts, adjacency and incidence matrices, incidence lists, Eulerian and Hamiltonian graphs, connected and planar graphs, graph traversal, weighted graphs. Graph algorithms: finding the minimum spanning tree, shortest path algorithms. Steiner tree, Small World phenomenon, vertex and edge coloring of graphs and their applications, graph coloring algorithms, rooted labeled trees, representation of arithmetic expressions, Polish notation. Networks. Event networks, network flows, max-flow min-cut theorem.	ID1A_W01 ID1A_W08 ID1A_U01 ID1A_U07 ID1A_K01
16.	Organization of Computer Systems	7	Overview of basic data representation standards. Boolean arithmetic. Design of combinational circuits. Methods for optimizing combinational circuits. Design of sequential circuits. Data flow analysis on timing diagrams. Operation of basic digital blocks (adders, registers, memory). Architecture of single-cycle, multi-cycle, and pipelined processors. Fundamentals of MIPS architecture. Basics of machine language. Microarchitecture (single-cycle, multi-cycle, and pipelined architecture). Types of memory (cache, virtual memory).	ID1A_W11 ID1A_U05 ID1A_U06 ID1A_K03
17.	Numerical Methods in Physical Applications	2	Introduction to numerical errors. Finite and iterative methods for solving linear and nonlinear equations and systems of equations. Nonparametric least squares approximation of physical measurement data, algebraic and orthogonal polynomials. Function minimization methods. Parameter fitting of mathematical models of physical systems to experimental data. Integration of ordinary and partial differential equations. Numerical solutions of models of selected physical phenomena. Application of the Monte Carlo method in modeling physical processes.	ID1A_W01 ID1A_W02 ID1A_W08 ID1A_U01 ID1A_U02 ID1A_U05 ID1A_U07

				ID1A_U08 ID1A_U09 ID1A_U13 ID1A_K03 ID1A_K04
18.	Physics Laboratory	8	As part of the Laboratory, students carry out experiments in various areas of physics (mechanics, heat, electricity, magnetism, optics). Students are required to master the material specified in the question sets for each experiment, included in the corresponding instruction manuals. The topics, order, and methods of conducting experiments, as well as the requirements for lab reports and data analysis, are provided in the documentation and syllabus of the Physics Laboratory.	ID1A_W03 ID1A_W04 ID1A_U02 ID1A_U03 ID1A_U13
19.	Stochastic Processes in Physics	4	Definition and examples of processes in discrete and continuous systems. Functions of random variables. Fourier and Laplace transforms. Characteristic function. Correlation and power spectrum, harmonic analysis of stochastic processes. Stationary processes. Markov and non-Markov processes. Chapman-Kolmogorov equation. Models of stochastic processes in physical sciences. Birth and death processes. Models of radioactive decay. Malthus-Verhulst population growth model. Brownian motion models. Diffusion and reaction–diffusion processes. 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 describe selected physical processes, in particular anomalous diffusion processes, and stochastic interpretation of these equations.	ID1A_W02 ID1A_W11 ID1A_W12 ID1A_U01 ID1A_U05 ID1A_U08 ID1A_U12 ID1A_U13 ID1A_K01 ID1A_K03
20.	Statistics 1	4	Basic statistical concepts. Classification of statistical variables. Design of a statistical study. Grouping and presentation of statistical data. Numerical characteristics of a population structure: measures of central tendency, dispersion, skewness, and concentration. Random sampling, sampling distributions. Concept of an estimator, properties of “good” estimators. Basic methods of constructing estimators. Point and interval estimation of population parameters. Issue of minimum sample size. Statistical hypothesis testing. Types of errors in hypothesis testing. Statistical power of a test. Hypothesis testing for population parameters (Student’s t-tests, one- and two-way ANOVA). Nonparametric tests. Goodness-of-fit tests. Correlation analysis and introduction to linear regression.	ID1A_W02 ID1A_U01 ID1A_U05 ID1A_U06 ID1A_U13 ID1A_K01
21.	Statistics 2	4	Forms of representation of multivariate data. Methods of graphical presentation. Descriptive analysis of multivariate data. Measures of location and variability. Distance measures. Measures of dependence. Principal component analysis and its geometric interpretation. Multivariate normal distribution. Selected statistical tests. Multifactor analysis of variance. Modifications of variance analysis for ordinal variables. Selected issues in cluster analysis and object classification. Model-based cluster analysis. Bayesian classifiers.	ID1A_W02 ID1A_U01 ID1A_U05 ID1A_U06 ID1A_U13 ID1A_K01
22.	Basics of Neural Networks	5	Neuron model, sigmoid function, perceptron, neural network, biological analogy. Associative and hetero-associative memory. Supervised learning, backpropagation, unsupervised learning. Examples of applications in data processing. Hopfield and Kohonen networks. Computer modeling of simple neural networks.	ID1A_W06 ID1A_W07 ID1A_W16 ID1A_U07

				ID1A_K01 ID1A_K02
23.	Computer Networks	4	Basic concepts and foundations of computer networks. LANs based on Ethernet technology. IP protocol. Transport layer: UDP and TCP protocols. DNS. Wireless networks. Dynamic routing protocols. Application layer: FTP and HTTP protocols. Elements of cryptography. Basics of security: attacks and tunneling. Peer-to-peer networks, NAT, and firewalls.	ID1A_W10 ID1A_U08 ID1A_K01
24.	Databases	5	Types and models of modern databases. Structure, integrity, and normalization of a database. Relational database model: data organization, relational criteria, 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. Basics of the Structured Query Language (SQL): data types, creating, modifying, and deleting tables, populating tables with data, queries, subqueries, joins, aggregate functions, transactions, integrity constraints. Database management systems and their functions.	ID1A_W07 ID1A_W09 ID1A_W12 ID1A_U06 ID1A_U11 ID1A_U13 ID1A_K03 ID1A_K04
25.	Data Visualization Techniques	5	Introduction to issues related to graphical data presentation on the web. Introduction to the D3 library. Basics of the technologies used (HTML, DOM, CSS, JavaScript, SVG). Setting up the working environment (WAMP server, terminal with Python interpreter, referencing the D3 library). Data preparation (creating tags, binding data). Graphical data presentation (drawing using div elements, drawing using SVG elements, creating various types of charts). Updates, transitions, and animation (ordinal scales, event listener functions, updating scaling functions, joining data using keys). Interactivity (binding event listener functions, grouping SVG elements, tooltips). Chart layouts (e.g., pie chart, stacked chart, force-directed graph). Geographic maps (GeoJSON, paths, projections, choropleths). Exporting (bitmaps, PDF files, SVG files).	ID1A_W06 ID1A_W07 ID1A_W08 ID1A_U05 ID1A_U06 ID1A_K02
26.	Analysis of Experimental Data	4	Data from large detection systems: methods of data collection, recording, formatting, online selection, quality control, and data visualization. Data management, descriptive statistics, estimation, and hypothesis testing. Formats and structures of large physical data sets. Data analysis: methods of reading, offline selection, graphical preparation, and substantive interpretation of results. Correction of results for detector effects, acceptance, and unwanted physical effects. Use of simulation data from models based on the Monte Carlo method. Analysis of sample data sets obtained from research experiments and model data.	ID1A_W02 ID1A_W03 ID1A_W04 ID1A_W06 ID1A_W07 ID1A_W08 ID1A_W09 ID1A_W10 ID1A_U01 ID1A_U02 ID1A_U03 ID1A_U05 ID1A_U06 ID1A_U08 ID1A_U09

				ID1A_U10 ID1A_U11 ID1A_K01 ID1A_K04
27.	Experimental Data Sources	5	Sources of experimental data in physics and technical sciences. Types of data generated by measurement systems. Structure and format 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 raw experimental data analysis. Integration of experimental data with statistical analysis.	ID1A_W03 ID1A_W04 ID1A_W05 ID1A_W06 ID1A_W10 ID1A_W11 ID1A_U02 ID1A_U03 ID1A_U05 ID1A_U06 ID1A_U08 ID1A_U10 ID1A_U13 ID1A_K01
	Total of Field-Specific and Fundamental Courses	**117**		
			ELECTIVE COURSES:	
1.	Courses Related to the Preparation and Submission of the Diploma Thesis	17	**Diploma Seminar**: Ability to become familiar with the presented subject matter. Formulating a problem and finding a method for its solution. Preparing a presentation – a scientific communication. The role and practical execution of a report. Gathering, analyzing, and selecting materials. Formulating theses, discussing them, and defending them. Analyzing research progress in practical work. Preparing assumptions, their implementation, and documenting the work and obtained results. **Diploma Laboratory**: Work plan, outline. Selection of literature, references, plagiarism. Individual consultations to monitor the progress of work (simulations, programmed applications). Collecting and processing materials, writing the thesis.	ID1A_W01 – W16 ID1A_U09 ID1A_U11 ID1A_U12 ID1A_U14 ID1A_U15 ID1A_K01 ID1A_K02 ID1A_K04
2.	Elective Courses Broadening Students' Interests	51	Group Project Computer Systems Security Database Systems Evolutionary Algorithms Quantum Computers Machine Learning Deep Learning Data Exploration Algorithms Biostatistics Computer-Aided Design	ID1A_W01 – W16 ID1A_U01 – U15 ID1A_K01 – K04

			Java Programming C# Programming .NET Technologies Image Processing Cloud Data Engineering Big Data Systems and Distributed Processing Data Quality Management and Data Governance Virtualization of Server Environments Fundamentals of Multimedia Web Applications Mathematical methods in Physics Structure of Matter Fundamentals of Quantum Physics Introduction to Nuclear Physics Medical Informatics Astronomy Econophysics History of Science Game Theory	
3.	**PROFESSIONAL INTERNSHIPS** (scope, rules and format): **120 hours** The internship is carried out in various workplaces (e.g., IT enterprises and companies, laboratories, research centers) that enable full implementation of its detailed program.	6	Detailed program content is determined by the supervisor assigned at the institution where the student completes the internship. The objectives of the internship are: - to develop the ability to apply acquired theoretical knowledge in practice, - to understand the functioning of a given institution, - to become familiar with the nature of work in various positions and sectors related to the field of study, - to learn practical aspects of work in positions consistent with the chosen specialization, - to assess one's own potential in the job market, - to establish professional contacts.	ID1A_W10 – W16 D1A_U06 – U08 ID1A_U10 – U11 ID1A_U13 ID1A_U15 ID1A_K01 – K04
	Total elective courses	**74**		
Total – elective courses in the programme: 81 ECTS				
	TOTAL	**210**		

Full-time students are required to complete 60 hours of physical education classes; these classes are not assigned ECTS credits. Students are also required to complete a training course on safe and hygienic learning conditions, lasting no less than 4 hours, covering the specific nature of education at the university and the type of technical equipment used in the learning process. Additionally, students must complete a 2-hour library training session.

Foreign students are additionally required to:

Course	Minimum number of ECTS credits	Course content	
Polish Language Course for Foreigners	4	As part of this course, students will study Polish as a foreign language (language course), including content related to Polish culture (film, theatre), history, and traditions. The course will also focus on developing students' academic writing skills. **1. Lexical content**: Topics covered correspond to the content of coursebooks at the B2 level and include: school and university; fashion and appearance; employment and the labour market; shopping, trade, and consumption; Polish cuisine; public offices and services; economic vocabulary; political life in Poland; vocabulary related to nature and the environment; culture; religion and faith. **2. Grammar content**: Aligned with the syllabi of coursebooks at the B2 level for Polish as a foreign language and compliant with the Common European Framework of Reference for Languages (CEFR) of the Council of Europe. **3. Functional language use**: Aligned with the syllabi of B2-level coursebooks and enabling students to communicate effectively in Polish, including active participation in discussions, expressing emotions and opinions, argumentation, and presenting their point of view both orally and in writing, as well as delivering presentations.	ID1A_W12 ID1A_W13 ID1A_U11 ID1A_U12 ID1A_U14 ID1A_U15

14. METHODS FOR VERIFICATION AND ASSESSMENT OF LEARNING OUTCOMES ACHIEVED BY STUDENTS THROUGHOUT THE ENTIRE EDUCATIONAL CYCLE:

The course instructor defines specific learning outcomes and the methods of their verification, and includes them in the course syllabus. Achievement of all learning outcomes assigned to particular courses confirms the implementation of the educational concept for the programme and attainment of the programme learning outcomes. Verification and assessment of the learning outcomes achieved by students throughout the entire study cycle are carried out through:

- **Coursework** completed by students during their studies, such as: quizzes, tests, written assignments, reports, presentations, laboratory reports, and project work – according to instructions provided by the course instructor. All additional forms of assessment require corresponding guidelines.
- **Written and oral examinations** – the form of the examination is determined by the course instructor and specified in the course syllabus. The exam questions must not exceed the scope of the content included in the syllabus of the course.

- **Course credits and graded credits** – the course instructor determines the grading criteria, specifies its components, and provides a descriptive justification for the grade awarded to the student.
- **Diploma process** – includes the assessment of the engineering thesis by the supervisor and the reviewer, and passing the diploma examination.
- **Student internships** – the learning outcomes acquired during internships complement the educational concept. The verification of these outcomes is carried out in accordance with the internship regulations for each study programme.
- **Scientific club achievements** – feedback is obtained through external reviews (e.g. scientific publications, conference presentations, Rector's and Minister's scholarships).
- **Graduate tracking** – involves collecting feedback on the acquired knowledge, skills, and social competences, and their relevance in the labour market.
- **Employer opinion surveys** – involve employer feedback on study programmes, including the intended learning outcomes and methods of their verification.

The forms and methods of course delivery, as well as the assessment criteria and their components, are defined in the course syllabus. All forms of verification of the student's achievements obtained during the semester are recorded in the student's periodic achievement records.