STUDY PROGRAMME
Name of the field of study: Computer Science
effective from the academic year: **2025/2026**

Part I. General information.

1. Name of the unit conducting study: **Faculty of Computer Science**
2. Level of education: **undergraduate studies**
3. Educational profile: **general academic**
4. Number of semesters: **6**
5. Total number of ECTS points required to complete the study: **182**
6. Total number of hours in the course required to complete the study: **2210**
7. The programme accepted at the meeting of Faculty Board on: **26.02.2025**
8. International Standard Classification of Education (ISCED) code: **0613**
9. Prevailing discipline whereby more than a half of learning outcomes will be acquired, and proportional (%) share of individual disciplines whereby learning outcomes specified in the study programme will be acquired:

Name of the prevailing discipline	Proportional (%) share of the prevailing discipline
Computer Science	82%
Names of individual disciplines	Proportional (%) share of individual disciplines
Computer Science	82%
Mathematics	18%
Total:	100%

Part II. Learning outcomes

Descriptor of second degree PRK (Polish Qualifications Framework) specifications	Learning outcome symbol	Learning outcome description
KNOWLEDGE, a graduate is familiar with and understands:		
P6S_WG	KP6_WG1	the conceptual apparatus of logic and discrete mathematics, algebra and mathematical analysis.
	KP6_WG2	advanced issues of statistics and probabilistic methods.
	KP6_WG3	the concept of an algorithm and the principles of designing and analyzing algorithms.
	KP6_WG4	various techniques and methods of programming,

		paradigms and programming languages.
	KP6_WG5	principles of data collection and storage.
	KP6_WG6	advanced methods of approximate and exact calculations, understands the importance of error analysis in numerical calculations.
	KP6_WG7	possibilities resulting from the use of software for numerical calculations.
	KP6_WG8	methodologies and tools enabling software development in local, distributed and Internet environments.
	KP6_WG9	network communication methods and network security rules.
	KP6_WG10	principles of operation of various operating systems.
	KP6_WG11	selected advanced issues in the field of artificial intelligence, knowledge representation and processing, human-computer communication.
	KP6_WG12	methods and techniques of software engineering.
	KP6_WG13	methods, techniques and elements of architecture of distributed systems, fundamentals of parallel and distributed programming, models of parallel and distributed computing.
	KP6_WG14	fundamental concepts of automata theory and mathematical linguistics.
P6S_WK	KP6_WK1	legal and ethical issues related to computer science and health and safety rules when using computer equipment.
	KP6_WK2	selected dilemmas of modern civilization.
SKILLS, a graduate is able to:		
P6S_UW	KP6_UW1	apply the methods of algebra: conduct reasoning within the theory of algebraic structures, use the matrix apparatus to solve problems.
	KP6_UW2	apply methods of mathematical analysis to solve problems: concepts and properties of functions, sequences and series, limits and continuity of functions of one and many variables, differential and integral calculus of functions of one and many variables.
	KP6_UW3	use statistical and probabilistic methods to analyze data.
	KP6_UW4	use the apparatus of mathematical logic to describe and verify facts, apply inductive reasoning and deductive reasoning.
	KP6_UW5	formulate and interpret computer science concepts using mathematical constructions and

			computational methods.
		KP6_UW6	independently design algorithms that perform specified tasks, perform an analysis of the complexity of a given algorithm.
		KP6_UW7	choose the appropriate paradigm and programming language to solve specific types of tasks.
		KP6_UW8	independently implement algorithms using appropriate elements of a selected programming language.
		KP6_UW9	solve algebraic and analytical problems numerically.
		KP6_UW10	apply numerical computing software to solve problems, estimate the error of numerical calculations, can implement known numerical algorithms in a selected programming language.
		KP6_UW11	design and optimize a database according to a specification, effectively search for desired information in existing databases, implement a database in a selected database system.
		KP6_UW12	design a local computer network, administer a local computer network ensuring security.
		KP6_UW13	use the capabilities of different operating systems in computer systems that perform different functions.
		KP6_UW14	describe problems expressed in natural language in terms of artificial intelligence.
		KP6_UW15	use design patterns, use API, use tools supporting the process of creating, testing and debugging software.
		KP6_UW16	use knowledge in the field of automata theory and formal languages to solve simple problems in the field of human-computer communication, artificial intelligence, formulating algorithms and designing simple information systems.
		KP6_UW17	create client-server software.
		KP6_UW18	use Internet-based software development technologies.
		KP6_UW19	use parallel computing to increase the efficiency of solving an algorithmic problem, select an appropriate algorithm for a model of parallel and distributed computing.
		KP6_UW20	implement a solution to a problem that requires communication between processes in a distributed environment using available software.

	KP6_UW21	digitally model selected phenomena and simulate computationally simple processes, can optimize digital representations of phenomena and processes.
	KP6_UW22	use selected computational models.
P6S_UK	KP6_UK1	use computer science terminology in a foreign language at B2 level.
	KP6_UK2	prepare a study of given computer science topics and present them.
	KP6_UK3	independently develop a solution to a given computer science problem on the border of theory and practice and present the solution and conclusions.
P6S_UO	KP6_UO1	work in a programming team on a comprehensive solution to a given problem.
	KP6_UO2	work together as a group on joint projects.
P6S_UU	KP6_UU1	improve their skills and qualifications, monitor the development of computer science technologies and tools.
SOCIAL COMPETENCE, a graduate is prepared for:		
P6S_KK	KP6_KK1	careful lying priorities and prioritizing their activities.
P6S_KO	KP6_KO1	showing the proper attitude necessary to undertake practical activity in the information society.
P6S_KR	KP6_KR1	compliance with ethical and legal principles related to activity in the IT environment.

Part III. Description of the process whereby learning outcomes are acquired.

Group of courses 1, Programming

Group of courses 1/1, Algorithms and Data Structures
Symbols of learning outcomes: KP6_WG1, KP6_WG3, KP6_UW4, KP6_UW6, KP6_UW8, KP6_UU1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Methods of describing, designing and analyzing algorithms. Recursion, divide and conquer strategy, greedy algorithms, etc. Complexity of algorithms. Fundamentals of optimizing code and programs. Force algorithms. Software and hardware implementation of algorithms. Abstract data structures and ways to implement them. Basic algorithmic problems and algorithms related to trees, graphs, texts, sets, etc.

Group of courses ½, Structured Programming

Symbols of learning outcomes: KP6_WG1, KP6_WG3, KP6_WG4, KP6_UW6, KP6_UW7, KP6_UW8, KP6_UU1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

The concept of algorithm and program, pseudocode. Basic data types and operators in high-level languages on the example of C language. Complex data: arrays, structures, strings. Arithmetic operators and assignment operator, operator precedence, expressions, type conversions. Simple and structured, conditional and iterative statements. Basic input/output instructions. Logical operators, functions. Subprograms, ways of passing parameters, recursion. Memory management. Pointers, reference and dereference, dynamic memory management. Structures, custom data types. File support. Program invocation options. Functions with a variable number of arguments. Preprocessor, standard library.

Group of courses 1/3, Object-Oriented Programming

Symbols of learning outcomes: KP6_WG1, KP6_WG3, KP6_WG4, KP6_WG5, KP6_UW6, KP6_UW7, KP6_UW8, KP6_UW15, KP6_UK1, KP6_UK3, KP6_UU1, KP6_KK1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Philosophy and basic techniques of object-oriented programming on the example of C++. The use of the most important techniques of object-oriented programming in practice. Design, implementation and analysis of programs in the object-oriented paradigm.

Group of courses ¼, Python Programming

Symbols of learning outcomes: KP6_WG3, KP6_WG4, KP6_UW6, KP6_UW7, KP6_UW8, KP6_UW15, KP6_UK1, KP6_UK3, KP6_UU1, KP6_KK1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Python environment. Basic and advanced Python constructs. Simple and complex data types. Functions, modules and packages. Operators. File operations. Error and exception handling. Software testing. GUI. Data visualization and processing. Key aspects of object-oriented programming. Programming paradigms (structural, object-oriented, functional). Designing and implementing programs using selected Python packages and modules.

Group of courses 1/5, Java Programming

Symbols of learning outcomes: KP6_WG3, KP6_WG4, KP6_WG5, KP6_UW6, KP6_UW7, KP6_UW8, KP6_UW15, KP6_UK3, KP6_UU1, KP6_KK1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Introduction to the Java language. Object-oriented programming: inheritance, polymorphism. Exceptions programming - creating and using exceptions. Generic

programming: parameterized types, containers, comparators, iterators, algorithms. GUI. Event-driven programming.

Group of courses 1/6, Internet Programming

Symbols of learning outcomes: KP6_WG4, KP6_WG5, KP6_WG8, KP6_WG9, KP6_UW8, KP6_UW17, KP6_UW18, KP6_UK1, KP6_UO2, KP6_UU1, KP6_KO1, KP6_KR1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Web page description languages (HTML and CSS) and data representation and transformation languages (XML and XSLT). JavaScript and creating dynamic websites. Web server-side programming and access to databases using PHP. Client-server communication.

Group of courses 1/7, Graphical User Interface Programming

Symbols of learning outcomes: KP6_WG1, KP6_WG3, KP6_WG4, KP6_WG5, KP6_WG10, KP6_WG11, KP6_UW6, KP6_UW7, KP6_UW8, KP6_UW15, KP6_UK3, KP6_UO2, KP6_UU1, KP6_KK1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Programming a modern user interface for desktop window applications, in particular for the Windows operating system. Problems of mobile systems and systems available remotely via a website.

Group of courses 1/8, Parallel and Distributed Programming

Symbols of learning outcomes: KP6_WG13, KP6_UW19, KP6_UW20, KP6_UU1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Architecture of parallel and distributed systems. Classification of parallel computing models with shared and distributed memory. Classic problems of process synchronization: the problem of producer and consumer, the problem of feasting philosophers. Parallelization efficiency measures: Amdahl's and Gustafson's laws. Parallel programming using the MPI interface. Elements of programming GPU graphics processors in the CUDA environment. The use of graphical processors to accelerate calculations on the example of artificial intelligence issues using the PyTorch library.

Group of courses 2, Informatics Tools and Applications

Group of courses 2/1, Computational Methods

Symbols of learning outcomes: KP6_WG3, KP6_WG6, KP6_WG7, KP6_UW9, KP6_UW10, KP6_UU1, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Calculation of errors in arithmetic operations. Interpolation and approximation methods. Numerical integration (squares with fixed nodes, Gaussian quadratures). Solving systems of linear equations by approximate methods. Solving non-linear equations with one unknown.

Group of courses 2/2, Artificial Intelligence
Symbols of learning outcomes: KP6_WG11, KP6_UW14, KP6_UK3, KP6_UO2, KP6_UU1, KP6_KR1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Rough sets. Fuzzy sets. Artificial neural networks. Classification and grouping of objects. Searching the state space. Evolutionary algorithms. Implementation of a project with documentation consisting in the classification / grouping of objects using selected algorithms.

Group of courses 2/3, Elements of Automata Theory and Formal Languages
Symbols of learning outcomes: KP6_WG1, KP6_WG14, KP6_UW5, KP6_UW16, KP6_UW22, KP6_UK3, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Basic issues: languages and grammars, regular grammars, context-free grammars, finite automata, stack automata, Turing machines and their types, non-determinism, Chomsky's hierarchy, characterization of problem spaces due to undecidability and complexity.

Group of courses 2/4, Computer Systems Architecture
Symbols of learning outcomes: KP6_WG1, KP6_WG5, KP6_WG13, KP6_UW2, KP6_UW4, KP6_UW21, KP6_UO2, KP6_UU1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Digital technology and digital systems. Machine representation of data and implementation of arithmetic operations. Computer organization at the assembler level. Organization and architecture of memory systems. Interfaces and communication. CPU organization. Multiprocessing and alternative architectures.

Group of courses 2/5, Operating Systems
Symbols of learning outcomes: KP6_WG5, KP6_WG10, KP6_UW13, KP6_UK1, KP6_UO2, KP6_UU1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
General characteristics of operating systems. Identification of users and access to resources in the system. Redirection mechanism and building command pipelines. Unix data archiving and compression tools. Wildcard names and regular expressions. Overview of basic Unix utilities. Shell scripts. Process and thread management. The process of loading and booting the system. Mechanisms of concurrent operation. Task scheduling algorithms. Input/output devices and the file system. System operation in a

network environment. Routine administrative work. Practical ability to operate and manage operating systems.

Group of courses 2/6, Network Technologies
Symbols of learning outcomes: KP6_WG9, KP6_UW12, KP6_UU1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
ISO/OSI and TCP/IP protocol stack, IP addressing, routing, switching, virtual local area networks (VLANs), virtual private networks (VPNs), access control lists, firewalls.

Group of courses 2/7, Databases
Symbols of learning outcomes: KP6_WG5, KP6_UW11
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Introduction to databases. Relational model. Relational algebra. SQL language. Designing relational databases. Normalization. Normal forms. Conceptual design. Entity relationship diagram. Logical design. Physical design. Basic file structures. Indexing. Database transactions. Concurrency. Optimization.

Group of courses 2/8, Graphics and Technology for Computer Games
Symbols of learning outcomes: KP6_WG3, KP6_WG4, KP6_WG11, KP6_UW6, KP6_UW7, KP6_UW8, KP6_UW15, KP6_UK3, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Interaction with the user on the example of 2D game programming using the pyGame library: graphical structure, scenario, GUI interface. Parametric curves and patches of Bézier surfaces. Representation and processing of digital images: intensity change, blending, filtering, modifications with the use of histogram. The basics of 3D modeling using the Unity computer game engine: elements of the 3D scene, camera control, lighting, interaction with the user. Design and implementation of three-dimensional computer games based on the Unity engine.

Group of courses 3, Software Engineering

Group of courses 3/1, Software Engineering
Symbols of learning outcomes: KP6_WG8, KP6_WG12, KP6_WK1, KP6_UW15, KP6_UW21, KP6_UK2, KP6_UO1, KP6_UO2, KP6_UU1, KP6_KK1, KP6_KO1, KP6_KR1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Essential issues related to planning and conducting IT projects. Issues related to teamwork, customer collaboration, communications and documents. Rates and causes of failures of IT projects. Software engineering vs. system engineering vs. project management. Knowledge sources, professional organizations, and standards related to engineering IT solutions. Standards, software tools, systems engineering

professional organizations. Specific approaches to developing IT solutions: prototyping, model-based engineering, formal methods etc. Issues related to eliciting, specifying, and analysing requirements. Basics of modeling of IT systems and data by using UML, etc. Software configuration management, deployment and maintenance of systems. Software testing and quality management. Selected economic and legal aspects of software production: estimating price, licensing etc.

Group of courses 3/2, Designing Internet of Things (IoT) Systems
Symbols of learning outcomes: KP6_WG8, KP6_WG9, KP6_WG13, KP6_UW15, KP6_UW17, KP6_UW18, KP6_UK2, KP6_UK3, KP6_UO2, KP6_UU1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Introduction to Internet-of-Things: notions, components, applications. Tools and methods for developing IoT systems. Interaction of IoT devices with environtment: sensors, converters, servo motors etc. Hardware architectures of IoT devices. Software for IoT devices. Technologies and protocols related to communications. Architectures of distributed systems and server software. Selected advanced problem and solutions: handling big data, managing numerous devices, security.

Group of courses 3/3, Team Project
Symbols of learning outcomes: KP6_WG4, KP6_WG5, KP6_WG8, KP6_WG12, KP6_UW6, KP6_UW7, KP6_UW8, KP6_UW11, KP6_UW15, KP6_UW17, KP6_UK2, KP6_UK3, KP6_UO1, KP6_UO2, KP6_UU1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Creating in groups of 2-4 people programming projects in accordance with software engineering standards. Selection of the appropriate application development model, division of tasks among team members, development of a work schedule, writing and testing the application, preparation of project documentation. Project implementation.

Group of courses 4, Professional and Legal Issues in Informatics

Group of courses 4/1, Health, Safety and Ergonomics
Symbols of learning outcomes: KP6_WK1, KP6_UU1, KP6_KO1, KP6_KR1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Legal aspects of health and safety - employer's obligations, employee's obligations, factors particularly dangerous to human health, preventive health protection, accidents at work, occupational diseases, health and safety training. OHS in universities. Health and safety requirements for workstations equipped with screen monitors. Ergonomics - tasks. The man-machine-environment system. Workplace organization and ergonomics. Factors influencing work efficiency - noise, lighting, colors, microclimate, stress, physical and mental strain of the employee, breaks at work. Ergonomics in designing a computer workstation.

Group of courses 4/2, Intellectual Property Rights
Symbols of learning outcomes: KP6_WK1, KP6_UU1, KP6_KO1, KP6_KR1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Copyright in the intellectual property system. Work as a subject of copyright. The creator of the work and its copyright. Copyright trading. Scientific works. Special regulations of copyright protection. Copyright in digital technologies. Related law, image protection, addressee of correspondence and confidentiality of information sources. Consequences of copyright infringement.

Group of courses 5, Mathematics Courses

Group of courses 5/1, Review of Mathematics
Symbols of learning outcomes: KP6_WG1, KP6_UW2, KP6_UW4
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Basic functions, their properties and graphs, operations on functions. Trigonometric functions and their properties. Properties of exponents, exponential function, quadratic function, quadratic equations and inequalities, Viete's formulas. Polynomials, polynomial equations and inequalities, Bezoute's theorem. Exponential and logarithmic function. Rational functions. Arithmetic sequence, geometric sequence.

Group of courses 5/2, Mathematical Analysis 1
Symbols of learning outcomes: KP6_WG1, KP6_UW2, KP6_UW4
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Number sets. Relations, elementary functions of the real variable and their properties. The principle of mathematical induction. Number sequences. Number series. The limit of a function of one variable. Function asymptotes. Continuity of functions. The derivative of a function of one variable and its properties. Derivative of the inverse and composite function. Increments and differentials. Extremes of a function of one variable. L'Hospital's rule. Higher order derivatives.

Group of courses 5/3, Mathematical Analysis 2
Symbols of learning outcomes: KP6_WG1, KP6_UW2, KP6_UW4
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Power series. Taylor series. The concept of antiderivative and indefinite integral. Integration of rational, irrational and trigonometric functions. Riemann definite integral. Improper integral. Elements of topology, metric space. Functions of multiple variables: domain, limits of functions, graphs. Partial derivatives. Schwarz's theorem. Directional derivative, gradient. The derivative of an implicit function. Extremes of functions of many variables. Jacobian. Polar coordinates. Double and triple integrals over the normal area. Application of integrals in geometry and physics.

Group of courses 5/4, Differential and Difference Equations
Symbols of learning outcomes: KP6_WG1, KP6_UW2, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Types of ordinary differential equations, methods of solving differential equations. Some applications of first order differential equations. Difference equations.

Group of courses 5/5, Linear Algebra with Analytical Geometry
Symbols of learning outcomes: KP6_WG1, KP6_UW1, KP6_UW4
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Complex numbers, general and trigonometric forms, operations on complex numbers. Matrix calculus, rank of a matrix. Determinants, their properties and applications. Systems of linear equations, Gaussian elimination and Cramer's rule. Elements of analytical geometry to the extent necessary in the work of a computer specialist.

Group of courses 5/6, Logic and Set Theory
Symbols of learning outcomes: KP6_WG1, KP6_UW4, KP6_UW5, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Essential laws of classical propositional calculus. Quantifier logic. Using the laws of logic in order to express thoughts correctly and to conduct correct reasoning formulating proofs in the system of natural deduction. Basic concepts and methods necessary to understand more advanced mathematical theories (sets, relations and functions in set theory). Formal construction and modeling of mathematical objects based on set theory. Inductive reasoning.

Group of courses 5/7, Discrete Mathematics
Symbols of learning outcomes: KP6_WG1, KP6_WG3, KP6_UW2, KP6_UW4, KP6_UW6
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Mathematical induction and recursive definitions. Basic combinatorial issues. Problems and methods of graph theory. Euler's cycle and Hamilton's cycle. Elements of number theory: divisibility, Euclid's algorithm, congruences.

Group of courses 5/8, Probabilistic Methods and Statistics
Symbols of learning outcomes: KP6_WG2, KP6_UW3, KP6_UU1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Random variable. Discrete probability. Continuous probability. Probability distributions. Expected values, variance, standard deviation. Stochastic processes. Sampling. Estimation. Hypothesis testing. Correlation and regression. Computer methods of statistics.

Group of courses 6, Humanities and Social Sciences Courses

Group of courses 6/1, Humanities Elective Course
Symbols of learning outcomes: KP6_WK2, KP6_KO1, KP6_KR1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Students choose one humanities course from the list of courses approved by the Institute of Computer Science Council on the basis of a description compliant with the University of Bialystok regulations.

Group of courses 6/2, Social Sciences Elective Course
Symbols of learning outcomes: KP6_WK2, KP6_KO1, KP6_KR1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Students choose one social sciences course from the list of courses approved by the Institute of Computer Science Council on the basis of a description compliant with the University of Bialystok regulations.

Group of courses 6/3, Computer and Information Ethics
Symbols of learning outcomes: KP6_WK1, KP6_WK2, KP6_KO1, KP6_KR1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Computer and information ethics definitions. The origins of computer and information ethics. Computers in the workplace. Software ownership. Privacy and anonymity. Professional responsibility of computer specialists. Professional codes of computer scientists. Computer crimes.

Group of courses 7, Diploma Courses

Group of courses 7/1, Diploma Preparation Class 1
Symbols of learning outcomes: KP6_UK2, KP6_UK3, KP6_UU1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Guiding the student to develop and write a diploma thesis. Description of the justification for the purpose of the diploma thesis, description of the current state of knowledge related to the topic of the thesis, searching for information in the literature, also in foreign languages, planning, conducting and critical evaluation of experiments, presenting the results of research in a self-written thesis. The content is selected in relation with the subjects of students' diploma theses.

Group of courses 7/2, Diploma Preparation Class 2
Symbols of learning outcomes: KP6_UK2, KP6_UK3, KP6_UU1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Guiding the student to develop and write a diploma thesis. Description of the justification for the purpose of the diploma thesis, description of the current state of knowledge related to the topic of the thesis, searching for information in the literature, also in foreign languages, planning, conducting and critical evaluation of experiments, presenting the results of research in a self-written thesis. The content is selected in relation with the subjects of students' diploma theses.

Group of courses 7/3, Diploma Seminar 1
Symbols of learning outcomes: KP6_UK2, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Presentation of students' research results achieved during preparation of their diploma theses, improvement of skills of communicative transfer of knowledge, presentation of issues from the list of exam topics. The range of presentation topics corresponds to the topics of prepared theses.

Group of courses 7/4, Diploma Seminar 2
Symbols of learning outcomes: KP6_UK2, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Presentation of students' research results achieved during preparation of their diploma theses, improvement of skills of communicative transfer of knowledge, presentation of issues from the list of exam topics. The range of presentation topics corresponds to the topics of prepared theses.

Group of courses 8, General Education
Student choose to study one of the following foreign languages.

Group of courses 8/1, Russian
Symbols of learning outcomes: KP6_UK1, KP6_UO2, KP6_UU1, KP6_KK1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Active use of a foreign language at the B2 language level according to the Common European Framework of Reference for Languages in everyday communication situations (travelling, media and means of communication, problems of the modern world, education), as well as the ability to understand and use IT terminology in contacts with specialists in the field of information technology (electronic devices, data security, communication systems, computer engineering, information technology development). Using foreign-language sources covering general, academic and specialist issues relevant to the field of study.

Group of courses 8/2, German
Symbols of learning outcomes: KP6_UK1, KP6_UO2, KP6_UU1, KP6_KK1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Active use of a foreign language at the B2 language level according to the Common European Framework of Reference for Languages in everyday communication situations (travelling, media and means of communication, problems of the modern world, education), as well as the ability to understand and use IT terminology in contacts with specialists in the field of information technology (electronic devices, data security, communication systems, computer engineering, information technology development). Using foreign-language sources covering general, academic and specialist issues relevant to the field of study.

Group of courses 8/3, Physical Education
Symbols of learning outcomes: KP6_UO2
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Health and safety rules during physical education classes, regulations for using the sports facility. Learning basic technical and tactical elements. Educating students about the need to take care of their physical condition and supporting the development of social competences regarding group cooperation.

Group of courses 9, Elective Courses

Group of courses 9A, Advanced Programming Technologies
One course chosen from the following at least four announced by the Dean during the academic year:

Group of courses 9A/1, Functional Programming
Symbols of learning outcomes: KP6_WG1, KP6_WG4, KP6_WG11, KP6_UW4, KP6_UW7, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Introduction to the lambda calculus, a functional programming paradigm. Familiarization with a selected functional language.

Group of courses 9A/2, Logic Programming
Symbols of learning outcomes: KP6_WG4, KP6_WG11, KP6_UW4, KP6_UW7, KP6_UW16, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Introduction to the logic programming paradigm. Introduction to the Prolog language.

Group of courses 9A/3, R Programming
Symbols of learning outcomes: KP6_WG4, KP6_WG8, KP6_UW7, KP6_UW8
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Syntax and semantics of the R language. Basic types (atomic, recursive, etc.). Atomic and complex types (matrix, arrays, factors, data frames) and operations on them. Functions. Conditional expressions and loops. Vectorized operations versus loops. Exception handling, software testing, code debugging. R and object-oriented

programming (e.g., S3, S4, RC, R6 classes). Integration of R with C++ and Python. R and functional programming. Managing the R environment.

Group of courses 9A/4, .NET Programming

Symbols of learning outcomes: KP6_WG4, KP6_WG8, KP6_UW7, KP6_UW8, KP6_UU1, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Foundations and characteristics of the .NET platform and similar techniques. Implementation of .NET programs using the WPF engine. Creating a declarative user interface for WPF using XAML. Creating a fully scalable and universal interface for different resolutions.

Group of courses 9A/5, Design Patterns

Symbols of learning outcomes: KP6_WG4, KP6_WG8, KP6_UW7, KP6_UW8, KP6_UU1, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Origin and application of design patterns and examples of their use in practice. Recognizing the possibility of using design patterns in IT projects. Correct design and implementation of projects using design patterns on the example of Java.

Group of courses 9A/6, CUDA Programming

Symbols of learning outcomes: KP6_WG4, KP6_WG11, KP6_UW8, KP6_UW19, KP6_UK3, KP6_KK1, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Practical use of massively parallel computing acceleration on GPUs. Programming model of massively parallel processors and applications on the example of machine learning algorithms.

Group of courses 9A/7, Course 1 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9A/8, Course 2 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9B, Mobile and Web Application Programming

One course chosen from the following at least three announced by the Dean during the academic year:

Group of courses 9B/1, Interactive Web Applications in R Shiny

Symbols of learning outcomes: KP6_WG8, KP6_WG4, KP6_WG11, KP6_UW3, KP6_UW8, KP6_UW15, KP6_UW17, KP6_UW18 , KP6_UK1, KP6_UO1, KP6_UO2, KP6_UU1, KP6_KK1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Design and implementation of web applications (apps) with the Shiny web framework. The use of Shiny to create applications that allow for efficient analysis and reporting of data (in real-time). Creating interactive charts, simple simulations, and interactive

reports (dashboards). Working with selected Shiny support packages. The use of machine learning models in the application.

Group of courses 9B/2, Python Web Frameworks
Symbols of learning outcomes: KP6_WG8, KP6_WG4, KP6_UW8, KP6_UW15, KP6_UW17, KP6_UW18 , KP6_UK1, KP6_UO1, KP6_UO2, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Development of dynamic and efficient web applications using selected Python web frameworks i.e. Django and Flask. Dynamic, scalable, and secure website. Web application development scenarios. Defining business objectives, requirements, and functionality of the application. Design, implementation, and deployment of the application (product). Product design.

Group of courses 9B/3, Mobile Applications
Symbols of learning outcomes: KP6_WG3, KP6_WG9, KP6_UW6, KP6_UW8, KP6_UU1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Familiarization with the architecture of mobile systems. Mastering the basics of user interface design. Utilization of selected modern tools and frameworks supporting the development of mobile applications.

Group of courses 9B/4, Internet Frameworks and Libraries
Symbols of learning outcomes: KP6_WG4, KP6_WG8, KP6_UW7, KP6_UW8, KP6_UU1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
The essence and purpose of web frameworks. Overview of the most popular web frameworks and libraries.

Group of courses 9B/5, Course 1 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9B/6, Course 2 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9C, Data Analysis and Processing)
One course chosen from the following at least four announced by the Dean during the academic year:

Group of courses 9C/1, Natural Language Processing
Symbols of learning outcomes: KA6_WG11, KA6_UW7, KA6_UK3
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Introduction to natural language processing using the Python programming language and the Natural Language Toolkit (NLTK) library. Extracting information from unstructured and multilingual text, syntactic and semantic analysis. Using popular linguistic databases, including WordNet.

Group of courses 9C/2, Signal Processing and Analysis

Symbols of learning outcomes: KP6_WG4, KP6_WG11, KP6_UW8, KP6_UK3, KP6_UO1, KP6_UO2, KP6_KK1, KP6_UU1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Mathematical models of physical signals. Deterministic and stochastic signals. Discrete signal representations. Basic signal parameters (signal energy, average signal power and others). Sampling theorem. Convolution, deconvolution, correlation function. Fourier series, continuous Fourier transform, discrete Fourier transform. Wavelet analysis. Other signal transforms and their properties. Digital filters and their design. Signal analysis and processing using machine learning methods (including neural networks).

Group of courses 9C/3, Machine Learning in Data Analysis

Symbols of learning outcomes: KP6_WG5, KP6_WG11, KP6_UW3, KP6_UU1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Basic data types. Data preparation methods: cleaning, batch effects, data integration. Statistical methods. Classifiers (kNN, SVM, decision trees, random forests, XGBoost). Data clustering. Deep learning methods.

Group of courses 9C/4, Image Processing with Machine Learning

Symbols of learning outcomes: KP6_WG4, KP6_WG11, KP6_UW8, KP6_UK3, KP6_UO1, KP6_UO2, KP6_KO1, KP6_UU1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Introduction to digital image processing: image quality improvement; arithmetic operations; filtering and noise removal; edge detection; binary image operations; logical operations; image processing in the frequency domain; morphological methods: erosion, dilation, opening, closing. Examples of image processing methods. Image analysis: segmentation techniques, measurements of object parameters. Machine learning in image processing (including object recognition, selected machine learning algorithms, application of neural networks).

Group of courses 9C/5, Python in Data Analysis

Symbols of learning outcomes: KP6_UW3, KP6_UW6, KP6_UW8, KP6_WG2, KP6_UU1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Advanced data analysis with Python. Work with data in a variety of formats and use analysis of results to solve real-world problems. Prepare, manipulate, model and

visualise data. Intelligently process and analyse data using machine learning algorithms. Develop programming skills using mathematical and statistical tools.

Group of courses 9C/6, NoSQL Databases

Symbols of learning outcomes: KP6_WG5, KP6_UW11

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Introduction to NoSQL databases. NoSQL database models. Document databases. Key-value databases. Column-oriented databases. Graph databases. NoSQL architecture and scalability. Indexing in NoSQL. Security in NoSQL. Applications of NoSQL databases.

Group of courses 9C/7, Course 1 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9C/8, Course 2 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9D, Modelling and Simulation

One course chosen from the following at least three announced by the Dean during the academic year:

Group of courses 9D/1, Optimization Methods

Symbols of learning outcomes: KP6_WG1, KP6_WG3, KP6_UW8, KP6_UW9, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Formulation of the objective function with and without constraints. Necessary and sufficient conditions for extrema. Numerical methods of searching for the extremum of the objective function. Gradient methods. Nonlinear optimization with constraints. Quadratic programming. Simplex method in linear optimization.

Group of courses 9D/2, Computer Methods in Technology

Symbols of learning outcomes: KP6_WG6, KP6_WG7, KP6_UW5, KP6_UW21, KP6_UW22, KP6_UK3, KP6_UU1, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Basic concepts of computer modelling and simulation. Analysis of mathematical models. Boundary problems. Finite Difference Method (FDM). Boundary element method (BEM). Finite element method (FEM). Parametric integral equation system (PIES) as a computer method for 2D and 3D problems.

Group of courses 9D/3, Computer Statistics

Symbols of learning outcomes: KP6_WG2, KP6_WG4, KP6_UW3, KP6_UW7, KP6_UW21, KP6_UU1, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Fundamental concepts of the R language. RStudio as a GUI. Processing and statistical analysis of data using the R language. Building models and testing hypotheses. Visualization of results.

Group of courses 9D/4, Course 1 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9D/5, Course 2 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9E, Systems and Data Security
One course chosen from the following at least three announced by the Dean during the academic year:

Group of courses 9E/1, IT Security
Symbols of learning outcomes: KP6_WG9, KP6_WG10, KP6_UW12, KP6_UW13, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Physical security. Network security. Web application security. Security of operating systems. Penetration testing and Metasploit. Monitoring of resources. OSINT. Cyber Threat Intelligence.

Group of courses 9E/2, Server Administration
Symbols of learning outcomes: KP6_WG9, KP6_WG10, KP6_UW12, KP6_UW13, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Installation and configuration of server operating systems. Installation and configuration of selected servers (including web, email, web applications, DNS, SSH, etc.). Cloud solutions. Securing (strengthening) operating systems.

Group of courses 9E/3, Cryptography
Symbols of learning outcomes: KP6_WG9, KP6_UW6, KP6_UO2, KP6_UU1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Familiarization with the theory and selected cryptographic algorithms. Characteristics of secure IT systems. Basics of quantum cryptography. Development of programming skills utilizing mathematical tools.

Group of courses 9E/4, Course 1 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9E/5, Course 2 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9F, Applied Computer Science
One course chosen from the following at least four announced by the Dean during the academic year:

Group of courses 9F/1, E-Learning System
Symbols of learning outcomes: KP6_WG4, KP6_WG11, KP6_UW18, KP6_UK3, KP6_UO1, KP6_UO2, KP6_UU1, KP6_KO1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Remote learning rules and tools. Design, implementation and operation of e-learning platforms. Creating e-learning courses.

Group of courses 9F/2, LaTeX Typesetting System
Symbols of learning outcomes: KP6_WG11, KP6_UW4, KP6_UW7, KP6_UK2, KP6_UU1, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
The structure of documents of different classes. Fonts. Environments. Tables. Graphics. Definitions and redefinitions. Mathematical mode. Generating various indexes. Creating classes and packages. Dynamic presentations.

Group of courses 9F/3, Computer-Aided Theorem Proving
Symbols of learning outcomes: KP6_WG1, KP6_WG11, KP6_UW4, KP6_UW5, KP6_UO2, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Introduction to the Mizar computer system for verifying formalized mathematical proofs. Conducting and verifying various types of reasoning (assumption proofs, deductive and inductive reasoning, correctness of definitions).

Group of courses 9F/4, Medical Informatics
Symbols of learning outcomes: KP6_WG4, KP6_WG8, KP6_WG11, KP6_UW8, KP6_UK3, KP6_UO1, KP6_UO2, KP6_KK1
Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:
Acquisition and processing of medical signals and images. Computer systems and software for various levels of health care (doctor's office, clinic, outpatient clinic, hospital, standards for transferring patient documentation). Telemedicine and health telematics. Internet in medicine.

Group of courses 9F/5, Bioinformatics
Symbols of learning outcomes: KP6_WG4, KP6_WG11, KP6_UW3, KP6_UW8, KP6_UW14, KP6_UK3, KP6_UO1, KP6_UO2, KP6_UU1, KP6_KO1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

Introduction to molecular biology, sequence analysis of biomolecules, biological databases, introduction to the application of machine learning methods in the analysis of biomolecular data. Applications of R and Python languages in bioinformatics. Bioconductor and biopython libraries. Implementation of analytical protocols in R and Python.

Group of courses 9F/6, Intelligent Systems

Symbols of learning outcomes: KP6_WG11, KP6_WK1, KP6_WK2, KP6_UW7, KP6_UW22, KP6_UK3, KP6_UU1, KP6_UO2, KP6_KK1, KP6_KR1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

A survey of recent achievements in the field of intelligent systems: decision support systems, diagnostic systems, smart grid, transport, buildings, interfaces, autonomous vehicles and drones, GenAI. Introduction to deep learning. At lab, creation of an intelligent system or an AI module to be implemented in an intelligent system.

Group of courses 9F/7, Course 1 thematically related to the group, fulfilling any of learning outcomes

Group of courses 9F/8, Course 2 thematically related to the group, fulfilling any of learning outcomes

Group of courses 10, Apprenticeships

Symbols of learning outcomes: KP6_WK1, KP6_UK1, KP6_UK2, KP6_UU1, KP6_KO1, KP6_KR1

Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses:

General training in the field of health and safety and fire protection regulations. The role and tasks of IT in the company. Work structure and organization of the IT environment (organizational and legal issues regulating the tasks and rights of employees). Participation in the work of the company's IT specialists in at least two of the following areas: configuration and repair of computer hardware, installation and configuration of operating systems and application software, testing of hardware and systems, issues of computer hardware operation in the company; analysis and design of IT systems, implementation of IT systems; programming - joint work on projects in the company's programming teams using elements of software engineering; use of application software, software maintenance, work with databases used in the enterprise; infrastructure of computer networks in the enterprise, configuration and administration of its resources; protection of data, programs and processing and archiving processes, system and application software used in the enterprise.

The detailed content of the program is specified in the Framework program of student apprenticeships in the field of Computer Science introduced in the Regulations of

student apprenticeships at the Institute of Computer Science of the University of Bialystok.

Note: The student, depending on the selected company in which he or she does the internship, must meet at least one learning outcome in terms of knowledge (depth and extent) and at least two learning outcomes in terms of skills (use of knowledge).

The duration (in weeks and hours), rules and form of apprenticeships and the number of ECTS points that the student must obtain during these apprenticeships.

Apprenticeships continue for 3 weeks (120 hours / 160 didactic hours). Pass with a grade on the basis of a certificate issued by the employer, written opinion of the apprenticeships supervisor, based on the apprenticeship record. Number of ECTS credits: 6.

Pass with a grade on the basis of a certificate issued by the employer along with a written opinion of the company's apprenticeships supervisor, on the basis of the apprenticeship record and conversations of the tutor with students summarizing the apprenticeship. The apprenticeships are credited by the tutor on the basis of the above-mentioned documents submitted by the students.

Methods of verification and assessment of learning outcomes achieved by a student during the entire study cycle.

The methods of verifying and assessing the learning outcomes achieved by the student include: exam (written and/or oral), credit (written and/or oral), colloquium, project, paper, report, solving tasks, evaluation of laboratory work, activity in class and self-assessment of learning outcomes. Detailed methods of verifying and evaluating the learning outcomes achieved by the student are included in the subject syllabi. Detailed rules for obtaining credits for subjects and the year are set out in the Regulations of Studies of the University of Bialystok.

Conditions of graduation and conferred professional title.

The condition for completing studies and obtaining the professional title of Bachelor is to meet all the requirements provided for in the study programme, prepare a diploma thesis and pass the diploma examination.

Explanation of the symbols

P6S_WG – *description symbol of the second degree PQF*

P – *practical profile* **A** – *general academic profile*	**K –** *field learning outcomes* **A –** *educational profile (A – general academic, P – practical)*
P6 or P7 – PQF level *(6 – first degree study, 7 – second degree study and uniform master degree study)* **S** - *specification typical of qualifications obtained in higher education*	**6** – *educational level (6 - first degree study, 7 – second degree study and uniform master degree study)*
W – knowledge *(descriptive category)* **G –** *depth and extent* **K –** *context* **U – skills** *(descriptive category)*	

W – *use of knowledge*
K – *communicating*
O – *work organization*
U – *learning*
K – social competence *(descriptive category)*
K – *critical evaluation*
O – *responsibility*
R – *professional role*