

## STUDY PROGRAMME

**Name of the field of study: Computer Science**

effective from the academic year: **2023/2024**

### Part I. General information.

1. Name of the unit conducting study: **Institute 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 Institute Board on: **22.02.2023**
8. 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	81%
Names of individual disciplines	Proportional (%) share of individual disciplines
Computer Science	81%
Mathematics	19%
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.
<b>SKILLS, a graduate is able to:</b>		
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.
<b>SOCIAL COMPETENCE, a graduate is prepared for:</b>		
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. Learning programmes ensuring the achievement of learning outcomes for the courses or groups of courses.**

**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

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 1/2 (Structured Programming)**

Symbols of learning outcomes: KP6\_WG1, KP6\_WG3, KP6\_WG4, KP6\_UW6, KP6\_UW7, KP6\_UW8, KP6\_UU1

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

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 1/4 (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

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 (Programowanie w języku Java)**

Symbols of learning outcomes: KP6\_WG3, KP6\_WG4, KP6\_WG5, KP6\_UW6, KP6\_UW7, KP6\_UW8, KP6\_UW15, KP6\_UK3, KP6\_UU1, KP6\_KK1

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

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

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

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

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

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

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

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

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

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

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 Human-Computer Communication)**

Symbols of learning outcomes: KP6\_WG3, KP6\_WG4, KP6\_WG11, KP6\_UW6, KP6\_UW7, KP6\_UW8, KP6\_UW15, KP6\_UK3, KP6\_UU1, KP6\_KK1

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 1)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG5, KP6\_WG8, KP6\_WG12, KP6\_UW15, KP6\_UW17, KP6\_UU1, KP6\_KO1

Software life cycle processes and models. Classical and agile approaches to the development of IT systems. Requirements specification problems and solutions; analyzing, designing and implementing systems; planning and execution of works. Standards, software tools, systems engineering professional organizations. Fundamentals of the economics of software engineering.

#### **Group of courses 3/2 (Software Engineering 2)**

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

Basics of modeling IT systems and data using UML, etc. Selection of the programming paradigm and system architecture. The basics of using design patterns

and designing programmer interfaces (API) and user interfaces (GUI, UX).  
Maintenance  
and administration of IT systems: configuration management. Software quality, testing and verification.

### **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

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

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

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

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, Viète'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

Number sets. Relations, elementary functions of the real variable and their properties. The principle of mathematical induction. Number sequences. Number series.



### **Group of courses 5/3 (Mathematical Analysis 2)**

Symbols of learning outcomes: KP6\_WG1, KP6\_UW2, KP6\_UW4

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. Taylor series. Power series.

The concept of antiderivative and indefinite integral. Integration of rational, irrational and trigonometric functions. Riemann definite integral. Improper integral.

### **Group of courses 5/4 (Mathematical Analysis 3)**

Symbols of learning outcomes: KP6\_WG1, KP6\_UW2, KP6\_UW4

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 5/5 (Differential and Difference Equations)**

Symbols of learning outcomes: KP6\_WG1, KP6\_UW2, KP6\_KK1

Types of ordinary differential equations, methods of solving differential equations. Some applications of first order differential equations. Difference equations.

### **Group of courses 5/6 (Linear Algebra with Analytical Geometry)**

Symbols of learning outcomes: KP6\_WG1, KP6\_UW1, KP6\_UW4

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 5/7 (Logic and Set Theory)**

Symbols of learning outcomes: KP6\_WG1, KP6\_UW4, KP6\_UW5, KP6\_KK1

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 5/8 (Discrete Mathematics)**

Symbols of learning outcomes: KP6\_WG1, KP6\_WG3, KP6\_UW2, KP6\_UW4, KP6\_UW6

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 5/9 (Probabilistic Methods and Statistics)**

Symbols of learning outcomes: KP6\_WG2, KP6\_UW3, KP6\_UU1

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

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

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

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

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

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

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

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

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

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 8/4 (Physical Education)**

Symbols of learning outcomes: KP6\_UO2

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)**

Two courses to choose from:

#### **Group of courses 9A/1 (Component Programming)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_UW7, KP6\_UW8, KP6\_UU1, KP6\_KO1

Designing multi-layer component applications on the example of J2EE technology. Application architecture in J2EE. The MVC (Model-View-Controller) design pattern. Enterprise JavaBeans (EJB) technology. Types of EJB components. JDBC database access interface. Servlets in J2EE. Session management. Application security.

#### **Group of courses 9A/2 (.NET Programming)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_UW7, KP6\_UW8, KP6\_UU1, KP6\_KO1

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/3 (Design Patterns)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_UW7, KP6\_UW8, KP6\_UU1, KP6\_KO1

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/4 (Matlab Programming)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_UW7, KP6\_UW8, KP6\_UU1, KP6\_KO1

Matlab environment. Basic data types and programming constructs. 2D and 3D graphics. GUI. Use of selected toolboxes and built-in functions for numerical and analytical calculations. Processing and analysis of large data sets. Parallel programming.

#### **Group of courses 9A/5 (Internet Frameworks and Libraries)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_UW7, KP6\_UW8, KP6\_UU1, KP6\_KO1

The essence and purpose of web frameworks. Overview of the most popular web frameworks and libraries.

#### **Group of courses 9B (Diagnostic and Control Systems)**

One course to choose from:

##### **Group of courses 9B/1 (LabVIEW Programming)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_WG11, KP6\_UW8, KP6\_UK3, KP6\_UO1, KP6\_UO2, KP6\_KK1

Programming in the LabVIEW environment. Independent development of applications in the G language, support and modification of sample, complex applications

in the LabVIEW Environment. Creating applications for handling electronic measuring devices as well as acquisition and visualization of measurement data.

##### **Group of courses 9B/2 (Computer Measurement Systems)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_WG11, KP6\_UW8, KP6\_UK3, KP6\_UO1, KP6\_UO2, KP6\_KK1

Configuration and structure of the measurement system. Measurement interfaces. Digital to analog and analog to digital converters. Signal processing. ELVIS II+

educational platform. Elements of programming in the LabVIEW environment. Virtual and wireless measurement systems.

### **Group of courses 9B/3 (Digital Signal Processing)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG11, KP6\_UW8, KP6\_UK3, KP6\_UO1, KP6\_UO2, KP6\_KK1

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.

### **Group of courses 9B/4 (Medical Informatics)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG8, KP6\_WG11, KP6\_UW8, KP6\_UK3, KP6\_UO1, KP6\_UO2, KP6\_KK1

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 9C (Knowledge Representation and Processing)**

One course to choose from:

#### **Group of courses 9C/1 (Constructive Methods in Computer Science)**

Symbols of learning outcomes: KP6\_WG1, KP6\_WG11, KP6\_UW4, KP6\_UW5, KP6\_UO2, KP6\_KK1

Familiarization with the Mizar computer proof verification system by conducting and verifying various reasonings.

#### **Group of courses 9C/2 (Functional Programming)**

Symbols of learning outcomes: KP6\_WG1, KP6\_WG4, KP6\_WG11, KP6\_UW4, KP6\_UW7, KP6\_KK1

Introduction to the lambda calculus, a functional programming paradigm. Familiarization with a selected functional language.

#### **Group of courses 9C/3 (Logic Programming)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG11, KP6\_UW4, KP6\_UW7, KP6\_UW16, KP6\_KK1

Introduction to the logic programming paradigm. Introduction to the Prolog language.

#### **Group of courses 9C/4 (LaTeX Typesetting System)**

Symbols of learning outcomes: KP6\_WG11, KP6\_UW4, KP6\_UW7, KP6\_UK2, KP6\_UU1, KP6\_KK1

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 9D (Modelling and Simulation)**

One course to choose from:

#### **Group of courses 9D/1 (Computer Modelling and Simulation Methods)**

Symbols of learning outcomes: KP6\_WG1, KP6\_WG4, KP6\_WG8, KP6\_UW2, KP6\_UW7, KP6\_UW21, KP6\_UK2, KP6\_UK3, KP6\_UU1, KP6\_KK1, KP6\_KO1

The concept of model and computer simulation. System modelling stages. Cybernetic model and its modifications. Basics of physical modeling. The general (differential) form of the mathematical model and the stages of its creation. Application

of the operator method in mathematical modelling of systems. Classification and examples of mathematical models of selected systems. The process of building a simulation model.

### **Group of courses 9D/2 (Optimization Methods)**

Symbols of learning outcomes: KP6\_WG1, KP6\_WG3, KP6\_UW8, KP6\_UW9, KP6\_KO1

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/3 (Computer Statistics)**

Symbols of learning outcomes: KP6\_WG2, KP6\_WG4, KP6\_UW3, KP6\_UW7, KP6\_UW21, KP6\_UU1, KP6\_KO1

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 9E (Applied Computer Science)**

One course to choose from:

#### **Group of courses 9E/1 (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

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 9E/2 (Digital Image Processing)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG11, KP6\_UW8, KP6\_UK3, KP6\_UO1, KP6\_UO2, KP6\_KO1

Introduction to digital image processing: improving image quality; arithmetic operations; filtering and interference removal; edge detection; operations on binary images; logical operations; frequency domain image processing; morphological methods: erosion, dilation, opening, closing. Examples of applications of image processing methods. Image analysis: segmentation techniques, measurements of object parameters.

#### **Group of courses 9E/3 (Computer Methods in Technology)**

Symbols of learning outcomes: KP6\_WG6, KP6\_WG7, KP6\_UW5, KP6\_UW21, KP6\_UW22, KP6\_UK3, KP6\_UU1, KP6\_KO1

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 9E/4 (E-Learning Systems)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG11, KP6\_UW18, KP6\_UK3, KP6\_UO1, KP6\_UO2, KP6\_UU1, KP6\_KO1

Remote learning rules and tools. Design, implementation and operation of e-learning platforms. Creating e-learning courses.

#### **Group of courses 9E/5 (Graphics Cards Programming)**

Symbols of learning outcomes: KP6\_WG4, KP6\_WG11, KP6\_UW8, KP6\_UW19, KP6\_UK3, KP6\_KK1, KP6\_KO1

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 10 (Apprenticeships)**

Symbols of learning outcomes: KP6\_WK1, KP6\_UK1, KP6\_UK2, KP6\_UU1, KP6\_KO1, KP6\_KR1

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 Białystok.

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.

**Methods of verification (Apprenticeships):**

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

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



**K** – *critical evaluation*

**O** – *responsibility*

**R** – *professional role*

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