MINISTRY OF EDUCATION OF THE REPUBLIC OF AZERBAIJAN

Specialty (Program) Code and Title: 050509 – Computer Science

BAKU-2020

BACHELOR'S DEGREE CURRICULUM IN THE SPECIALTY OF "COMPUTER SCIENCE"

1. General Provisions

1.1. The Bachelor's Degree Curriculum in the specialty 050509 – Computer Science (hereinafter referred to as the "Curriculum") has been developed in accordance with the Law of the Republic of Azerbaijan "On Education", relevant resolutions of the Cabinet of Ministers

of the Republic of Azerbaijan, as well as the "Classification of Specialties (Programs) for the Bachelor Level (Basic Higher Medical Education) of Higher Education".

1.2. The objectives of the Curriculum are as follows:

- To define the graduate's competencies, the scope of the specialty, teaching and learning methods by subject, assessment methods, learning outcomes, requirements for infrastructure and human resources for personnel training, as well as opportunities for students to undertake internships, gain employment, and pursue further education;

- To inform students and employers about the knowledge, skills, and learning outcomes acquired by graduates;

- To inform the experts involved in evaluating the compliance of personnel training with the Curriculum.

1.3. The Curriculum is mandatory for all higher education institutions operating in the Republic of Azerbaijan, regardless of their subordination, type of ownership, or organizational-legal form, that provide bachelor's level (basic higher medical education) training in this specialty.

1.4. Under a five-day working week, the total weekly workload (including both in-class and out-of-class activities) for a student is 45 hours (excluding special-purpose higher education institutions). The volume of weekly in-class hours must not exceed 50% of the total weekly workload. Depending on the specifics of the specialty, the weekly workload may be adjusted.

2. Competencies of the Graduate

2.1. Upon completion of the Curriculum, the graduate is expected to acquire the following general competencies:

- Proficiency in oral and written communication in the Azerbaijani language within the context of the specialty;

- Communication skills in at least one foreign language relevant to the specialty;

- Systematic and comprehensive knowledge of the historical, legal, political, cultural, and ideological foundations of Azerbaijani statehood, as well as the ability to analyze the country's role and position in the modern world and forecast its future development;

- Ability to identify the challenges and threats facing the national state;

- Ability to effectively use information technologies in the workplace;

- Ability to work collaboratively in a team and contribute to joint problem-solving;

- Ability to adapt to new environments, demonstrate initiative, and maintain a strong determination to succeed;

- Ability to identify and select appropriate supplementary information resources for problem-solving.

- Ability to analyze, synthesize, and apply relevant information for professional purposes;

- Ability to plan and organize professional activities, improve future education and existing skills, manage time efficiently, and complete tasks on schedule;

- Ability to demonstrate social and environmental responsibility, civic awareness, ethical behavior, and a commitment to quality in professional activities;

- Ability to reassess situations and oneself for the purpose of developing knowledge and skills, including self-evaluation and self-criticism;

- Ability to draft and utilize normative and legal documents related to future professional activities, as well as to identify ways to restore violated rights;

- Ability to maintain a healthy lifestyle;

- Readiness for intercultural dialogue;

- Ability to develop habits of critical thinking and self-criticism;

- Ability to propose and justify new ideas;

- Ability to show initiative and take responsibility in challenging situations.

2.2. Upon completion of the Curriculum, the graduate is expected to acquire the following professional competencies: -Knowledge of the elements of set theory, the concept of limit of a sequence, limit and fundamental properties of single-variable functions, continuity of single-variable functions at a point and on a set, uniformly continuous single-variable functions on a set; understanding of the derivative and differential of single-variable functions, main theorems of differential calculus, higher-order derivatives and differentials, Taylor's formula for single-variable functions, extrema of single-variable functions, asymptotes of their graphs; knowledge of improper, definite, and indefinite integrals and their properties; understanding of numerical and functional sequences, the concept of the multi-dimensional Euclidean space; knowledge of the limit, continuity, and uniform continuity of multivariable functions; understanding of partial derivatives and differentials of multivariable functions, higher-order partial derivatives and differentials; Taylor's formula and extrema for multivariable functions; knowledge of parameter-dependent integrals, multiple Riemann integrals, line integrals, and surface integrals

- Must possess knowledge of complex numbers, functions of a complex variable and their differentiation, Cauchy-Riemann conditions, the concept of conformal mappings, regular functions, integration of functions of a complex variable, Cauchy's integral theorem, Cauchy's integral formula, Laurent series, classification of isolated singular points of regular functions, the concept of residues, the main theorem of residue theory, calculation of residues and their applications.

- Must be familiar with Cartesian coordinate systems in the plane and space, basic problems of analytic geometry, solutions to systems of two and three linear equations, elements of vector algebra, coordinate transformations, equations of lines and planes, properties of conic sections, second-order algebraic curves and surfaces.

- Must be able to perform operations on polynomials and matrices, understand the properties and calculation methods of determinants, apply Laplace's theorem, know linear spaces and their bases, solve systems of linear algebraic equations and methods for their solutions, understand the Kronecker-Capelli theorem, Euclidean space, orthogonalization methods, linear and bilinear transformations, quadratic forms and their classification.

- Must learn the fundamental concepts of mathematical logic, axiomatic methods, understanding of syntax and semantics, gain experience working with formal languages, basics of discrete mathematics, its applications in programming, main methods of discrete information processing, minimization of Boolean algebra and Boolean functions, elements of graph theory, types of graphs, typical properties, formulation of certain problems in graph form, solution methods, flow in networks, and trees.

- Must possess knowledge of first-order ordinary differential equations and systems of equations, methods for constructing solutions of nth-order ordinary differential equations, existence, uniqueness, and stability of solutions for Cauchy and boundary value problems, application of differential equations in mathematical modeling of various physical processes, classification of partial differential equations, derivation of mathematical physics equations describing various physical processes, formulation of Cauchy and boundary value problems for mathematical physics equations, types of boundary conditions and their physical interpretation, investigation of correctness for Cauchy and boundary value problems of mathematical physics equations, methods for solving Cauchy problems for hyperbolic and parabolic types of equations, and elements of harmonic functions and potential theory.

- Must know events and operations on them, various definitions of probability and calculation methods, application of total probability and Bayes' formulas, distribution laws of discrete and random variables and their numerical characteristics, main essence of the law of large numbers and central limit theorems, basic elements of mathematical statistics, statistical estimation based on distribution parameters, laws related to normal distribution, statistical parameter estimation and construction of confidence intervals, methods for testing statistical hypotheses.

- Must study approximation methods for functions, Lagrange and Newton interpolation polynomials and their error estimation, methods for finding roots of nonlinear equations and systems of nonlinear equations using simple iteration, bisection, Newton, and secant methods, numerical solution methods for systems of linear algebraic equations, their assembly and error estimation, numerical differentiation and integration methods and their error estimation, numerical solution methods for Cauchy problems for ordinary differential equations and systems, numerical methods for boundary value problems and integral equations for ordinary and partial differential equations, and application of numerical methods and computer technologies in constructing algorithms for solving specific problems.

- Must understand the necessary and sufficient conditions for extrema of single- and multivariable functions, constrained extrema, and the method of Lagrange multipliers; knowledge of convex sets, convex functions and their properties; linear and convex programming problems and their solution methods; the Kuhn-Tucker theorem; gradient method and penalty function method; classical variational problems; elements of optimal control theory; Pontryagin's maximum principle and its discrete analogue.

- Must possess fundamental knowledge of computer networks, their purpose and classification; hardware and software of local and wide area networks; ability to work within computer networks; knowledge of network topologies and various communication lines used for data transmission; ability to set up computer networks; understanding of different network models including the ISO-OSI model layers and operation principles; knowledge of various network technologies and client-server architecture; understanding of Internet services and protocols, domain names, and the TCP/IP protocol suite; ability to effectively use search engines and social networks on the Internet.

- Must be familiar with the development stages of computers and the von Neumann architecture; basic computer components (CPU, main memory), their operation principles and main characteristics; interconnection of computer components and the technical means enabling these connections (buses, controllers, drivers); peripheral devices (external storage, monitor, printers, keyboard, mouse, etc.), their operation principles and main characteristics; ability to compare different computers by technical parameters; ability to determine the configuration of a computer matching specified parameters.

- Must know the rules for constructing the structure of web pages using HTML; methods for designing and adding effects with CSS; ability to combine HTML and CSS for more effective web page layout; general understanding of ASP.NET, PHP and their general structure; ability to create and combine various styles using CSS and HTML; knowledge of using JavaScript to add functionality to web pages.

- Must have knowledge of technologies for creating large-scale software projects, covering all stages from problem definition to deployment; structured programming and object-oriented programming technologies; types of software quality control; methods of software debugging; classification, detection and elimination of errors; structural and functional testing methods; knowledge of methods for creating reliable software and information protection using modern programming technologies; knowledge of program structure creation and modular programming.

- Must have knowledge of parallel computing systems (multiprocessor and pipeline systems); principles and characteristics of parallelization in such systems; ability to design parallel algorithms for solving various problems; resource processing in single and multiprocessor systems; ability to manage node critical states; knowledge of algorithms for mutual exclusion in parallel processes; synchronization methods and fault tolerance mechanisms in distributed systems; ability to work with transactional processing and algorithms ensuring serializability of transactions; knowledge of Lamport’s clock and its working principle; understanding of transaction queuing according to logical timestamps, aborting delayed transactions, and

modified timestamp algorithms aimed at reducing aborted transactions; knowledge of mechanisms such as bi-locking, two-phase locking, deadlock, resources and queues for resources, transaction execution and rollback, and writing results to the database.

- Must know the functions, classification, and components of operating systems; concepts of processes and file systems and their management; tools for sharing and managing operational memory between programs; management of peripheral devices; knowledge about service programs of OS families like MS Windows and Linux; ability to operate and configure MS Windows for specific users; ability to diagnose and resolve certain failures in MS Windows.

- Must understand the mathematical foundations of algorithm analysis; methods for best, worst, and average-case analysis; search and sorting algorithms (sequential, binary search, etc.) and their analysis; ability to develop and analyze algorithms operating on data structures such as stacks, lists, and trees; knowledge of relations and solution methods; knowledge of main algorithm classes including dynamic programming algorithms; ability to estimate algorithm complexity; application of breadth-first and depth-first search algorithms for problem-solving and complexity estimation; ability to write pseudocode for search and sorting algorithms and analyze them; skills to find optimal algorithms and solve simple recurrence relations; knowledge of greedy algorithms, their implementation, and complexity evaluation.

- Must know the subject matter and components of computer science; perform operations on numbers in various numeral systems; understand fundamental principles of computer operation and data representation in memory; basic elements of algorithmization; programming of linear, branching, and looping algorithms; ability to develop linear programs and programs for branching and looping processes; knowledge of working with static and dynamic arrays and file organization; ability to solve problems using auxiliary functions, standard libraries, and dynamic variables; skills to solve problems related to queues, stacks, deques, and lists.

- Must understand fundamental concepts of information systems, ongoing processes within information systems, their development stages and application areas; structure of information systems and stages of information system development; operations on relational data, normalization forms, algorithms for bringing problems into normal form within the relational model; concepts of databases, methods of database organization, and data models; database management systems and query languages; ability to apply these to practical problems; skills to set tasks for automated information systems in any subject area, select suitable models, and create databases in SQL or Oracle.

- Must possess knowledge of the purpose of artificial intelligence development, classification of work conducted in this field, and main research directions. Should understand artificial intelligent systems, knowledge representation, classification of knowledge, logical models of knowledge representation, and problems of knowledge acquisition. Must be familiar with knowledge and knowledge bases, as well as characteristics that define knowledge. Should know models of knowledge representation including logical models, semantic models, frame models, production models, and object-oriented models. Must understand the classification of expert systems, technologies for their development, and application areas. Should know methods and strategies for search in expert systems and logical inference mechanisms.

- Must know the main branches of physics including classical mechanics, theory of relativity, molecular physics and thermodynamics, electrodynamics, wave optics, quantum physics, atomic and nuclear physics, including their fundamental laws and regularities, mathematical formulations, and be capable of performing basic experimental work, assessing results, and calculating errors in laboratory work.

- Must master the fundamentals of civil defense, including forces and means of civil protection, characteristics of emergencies, protection of the population during emergencies, educating the population on civil defense, use of individual and collective protective equipment, basics and assessment of industrial facilities' resilience during emergencies, as well as organization and implementation of measures to eliminate emergency consequences.

- Must have knowledge of the emergence, formation, and development of modern Azerbaijani statehood traditions; ability to analyze and study political, ideological, economic, and cultural factors in the formation of the modern Azerbaijani state; ability to systematically analyze Azerbaijan's role and position in the contemporary world. Must know about the ancient and medieval Azerbaijani statehood; creation of major empires by Azerbaijani people in the East during the 15th-18th centuries; loss of Azerbaijani statehood in the early 19th century and its political, economic, and social consequences; struggle for national statehood in Azerbaijan, establishment of the Azerbaijan Democratic Republic—the first republic period; the second republic and Azerbaijani statehood during the Soviet Empire; independence movement in the late 1980s and restoration of independent statehood; internal policy of the independent Republic of Azerbaijan including development of its socio-economic and legal bases; establishment of a secure international environment for protecting independent statehood; struggle for restoration of territorial integrity; knowledge of Azerbaijan’s emergence as a leading state in the Caucasus.

- Must understand the history of the Azerbaijani language, its development, and ways to enrich it. Should know about historical periods when the Azerbaijani language faced pressure and aggression from hostile forces, yet was preserved thanks to the national unity and pride of the people, and the contributions of prominent commanders and statesmen. Must possess skills in presentation, oratory, academic and business writing in Azerbaijani. Must have a strong command of the Azerbaijani language, and possess abilities to preserve and develop it. Should be capable of maintaining the language’s uniqueness, introducing the cultural heritage of other nations through translation, and communicating with them. Must be committed to protecting the purity of the Azerbaijani language, defending it against foreign elements, and ensuring its vitality.

- Must have presentation, oratory, academic, and business writing skills, both oral and written, in at least one foreign language. Should be capable of representing their nation’s national and moral values and achievements on the international stage. Must be able to analyze grammatical, lexical, and semantic structures of the foreign language. Should possess habits for exchanging ideas and experiences in the foreign language. With foreign language proficiency, must be able to work in teams, develop interpersonal communication skills, leadership abilities, and

integrate business activities with the learning process. Must master communicative, systematic, and functional qualities of the foreign language.

3. Structure of the Educational Program

3.1. The Educational Program shall consist of 240 ECTS credits, corresponding to a duration of 4 years. The credits are distributed as follows:

Table 1:

Number of courses	Course name	ECTS Credit
1	**History of Azerbaijan** During the teaching of this course, knowledge about the history of Azerbaijan is systematized by grouping it according to historical location, historical periods, statehood, personalities, economy, and cultural content. The course aims to provide young generations with profound knowledge about the historical past of our homeland, to develop historical thinking, and to instill the ability to objectively evaluate events occurring in society. Special attention is given to cultivating respect for statehood ideology, fostering feelings of respect for the past and confidence in the future, and nurturing patriotism among the youth.	5
2	**Business and Academic Communication in Azerbaijani Language** This course focuses on developing students' skills in making presentations, public speaking, academic writing, and business communication in the Azerbaijani language.	4
3	**Business and Academic Communication in a Foreign Language** Within the scope of this course, special emphasis is placed on developing students' abilities to make presentations, public speaking, academic and business writing, both oral and written, in one of the foreign languages relevant to their specialty.	4
	Elective Courses	
4	Philosophy	3
	Sociology	
	Constitution of the Republic of Azerbaijan and Fundamentals of Law	
	Ethics and Aesthetics	
	Logic	
	Introduction to Multiculturalism	
5	Information Technologies	3
	Information Management	
	Fundamentals of Entrepreneurship and Introduction to Business	
	Political Science	
Total:		30

Specialty Courses

1	**Mathematical Analysis** The Mathematical Analysis course is based on the differential and integral calculus of single-variable and multivariable functions, as well as the theory of sequences. Students mastering this course should acquire essential knowledge about numerical sequences, understand the concepts of limits, continuity, and uniform continuity of single- and multivariable functions, differential and integral calculus, numerical and functional sequences, and focus on learning their applications in applied mathematics and computer science problems.	12
2	**Complex Analysis** The Complex Analysis course studies complex numbers, differentiation and integration of functions of a complex variable, sequences of complex numbers, and the theory of residues. Students learning this course should pay special attention to operations on complex numbers, differential and integral calculus of complex variable functions, the concept of conformal mappings, regular functions and classification of their isolated singular points, Laurent series, and the calculation and applications of residues.	4
3	**Analytic Geometry** The Analytic Geometry course investigates the properties of spatial figures using algebraic methods. Students should focus on coordinate methods, vector calculus, equations of lines and planes, as well as the derivation and analysis of general and canonical equations of quadratic curves and surfaces.	4
4	**Linear Algebra** In the Linear Algebra course, students study matrices, the general theory of systems of linear algebraic equations, linear transformations, and quadratic forms. The course emphasizes operations on matrices, calculation and properties of determinants, various methods for solving systems of algebraic equations, and bringing quadratic forms to canonical form along with their applications.	4
5	**Discrete Mathematics** The Discrete Mathematics course covers elements of mathematical and predicate logic, graph theory, Boolean algebra, combinatorics, and relations between objects. Students	6

	should pay particular attention to the correct understanding of mathematical concepts, the application of various proof methods, and the preparation of optimal programs using discrete mathematical techniques.	
6	**Differential Equations** The Differential Equations course studies the mathematical models of dynamic systems (processes). Students mastering this course should focus on ordinary and partial differential equations, their types, and solution algorithms (methods).	6
7	**Probability Theory and Mathematical Statistics** This course explores the laws of probability governing large-scale homogeneous events, the methods for collecting and processing statistical data to obtain scientific and practical results. Students should pay particular attention to applications of probability definitions, calculation of numerical characteristics of random variables, problem solving using various theorems, statistical distribution laws of sampling, calculation of some characteristics of samples, and statistical estimation of sample parameters.	4
8	**Numerical Methods** The Numerical Methods course studies numerical solution techniques in algebra, analysis, and differential equations. Students should focus on selecting appropriate solution methods, constructing difference schemes for differential equations, developing computational algorithms to solve them, implementing these algorithms on computers, applying them to practical problems, and understanding key concepts such as approximation, stability, convergence of difference schemes, and error sources and their estimation.	9
9	**Optimization Methods** This course studies solution methods for linear programming, convex programming, dynamic programming, and optimal control problems. Students should focus on learning various methods and their algorithms, computer implementations, and their application to practical problem solving.	5
10	**Fundamentals of Programming** Within this course, students acquire knowledge of basic elements of algorithmization, programming tools, writing linear programs, and programming branching and iterative processes.	14

11	**Algorithm Analysis and Design Methods** Students learn to design and analyze algorithms, understand the mathematical foundations and methods for algorithm analysis, evaluate algorithm complexity, and apply algorithms to solve specific problems.	8
12	**Programming Technologies** This course covers all stages of software project development, emphasizing skills for creating reliable software using modern programming technologies.	5
13	**Database Systems** Students learn about stages of information system development, database concepts, database management systems, and practical application of these systems for problem-solving.	5
14	**Computer Architecture** This course introduces students to the stages of computer development and Von Neumann architecture, main and peripheral computer devices, and their operating principles.	5
15	**Computer Networks** Students study the purpose, classification, hardware, and software of computer networks, network topologies, communication lines, various network technologies, and develop skills for working with internet search systems and social networks.	6
16	**Web Technologies** This course focuses on skills for building web page structures using HTML, applying design and effects with CSS, and adding functionality with JavaScript.	4
17	**Parallel and Distributed Computing** Students learn about parallel computing systems, principles and characteristics of parallelization, constructing parallel algorithms for problem-solving, synchronization methods in distributed systems, and fault tolerance mechanisms.	4
18	**Artificial Intelligence** This course introduces artificial intelligence systems, knowledge and knowledge bases, knowledge representation models, expert system classifications, search methods and strategies, and logical inference mechanisms.	4
19	**Operating Systems** Students learn the functions, classification, and components of	5

	operating systems, the concepts of processes and file systems, memory management, peripheral device control, and the working principles of utility programs in OS families such as MS Windows and Linux.	
20	**Physics** This course covers the fundamental laws and regularities of various physics branches, their mathematical expressions, certain experimental skills, evaluation of laboratory results, and error calculation.	3
21	**Civil Defense** This course provides knowledge on the fundamentals of civil defense, its forces and means, characteristics of emergency situations, protection of the population during emergencies, and raising public awareness on civil defense. It covers methods for mitigating the consequences of emergencies, the use of individual and collective protective equipment, and the basics of ensuring and assessing the operational resilience of industrial facilities during emergencies.	3
Total:		120

"Courses determined by the higher education institution"

Total:	60

Internship

Internship	30
Total:	240

4. Teaching and Learning

4.1. The teaching and learning environment should be organized in such a way that students can achieve the learning outcomes specified in the educational program.

4.2. Teaching and learning methods should be described in relevant documents (for example, in the teacher's syllabus, etc.) and made publicly accessible (for example, on the university's website, program brochures, etc.).

4.3. Teaching and learning methods should be continuously reviewed and improved, taking into account innovative educational practices. The regular improvement of teaching and learning methods should be an integral part of the university's quality assurance system.

4.4. Different teaching methods should be used during the learning process. These methods should promote a student-centered approach and encourage active participation of students in the learning process. Examples of teaching and learning methods that can be used include:

- lectures, seminars, practical assignments;

- presentations and discussions, debates;

- independent work/research (e.g., working with practical examples);

- projects;

- problem-based learning;

- fieldwork;

- role plays;

- reports;

- group assessments;

- expert method;

- video and audio conferencing technologies;

- video and audio lectures;

- distance learning;

- simulations;

- etc.

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4.5. A balance between theoretical education and practical training should be maintained. The main focus must be on strengthening practical skills in accordance with the changing needs of the labor market.

4.6. The educational program should support students' independence and foster the concept of lifelong learning. By the end of the educational process, students should be able to work independently in any direction and have the ability to continue their education throughout their lives.

5. Assessment

5.1. Assessment should be organized in such a way that the achievement of the expected learning outcomes by students can be effectively measured. This should help monitor progress, evaluate the extent to which the educational program's outcomes have been achieved, facilitate feedback and discussion with students, and support the formation of initial conditions for the improvement of the educational programs.

5.2. Assessment methods must be described in relevant documents (for example, in the course syllabus, program documentation, etc.) and be accessible to everyone (for example, on the university's website, program brochures, etc.).

5.3. Assessment methods should be continuously reviewed and improved, taking into account innovative teaching practices. The regular updating of assessment methods should be part of the quality assurance system of the higher education institution.

5.4. Different assessment methods should be used in the teaching process. These methods should encourage a student-centered approach and promote active participation of students in the learning process. Examples of assessment methods that may be used include:

- written assignments;

- knowledge and skills tests, computer-based tests;

- oral presentations;

- surveys;

- open discussions;

- practice reports, fieldwork reports;

- assessment of skills based on observations in practice and laboratory;

- reports on project work;

- portfolio assessment;

- frontal questioning;

- group and self-assessment;

- etc.

5.5. The methods used to assess learning achievements should be based on clearly defined criteria and must allow accurate and reliable determination of the student's level of knowledge, skills, and abilities acquired during the educational process. When evaluating learning outcomes, teachers should adhere to the principles of transparency, impartiality, mutual respect, and humanism.

5.6. Students should be given the opportunity to discuss all aspects of their education with teachers and evaluators, including the assessment process itself. The higher education institution must establish procedures for the assessment process and appeal related to grading.

5.7. Academic ethics holds an important place in the educational process. Students are taught to observe academic integrity and to understand the problem of plagiarism. They must be informed about intellectual property rights related to their intellectual work.

6. Learning Outcomes of the Program and Each Course

6.1. The determination of the learning outcomes of the educational program, as well as the learning outcomes of each course and the preparation of each course syllabus, are the authority of the higher education institution/academic staff.

6.2. Learning outcomes are determined by each higher education institution according to the form in Annex 1. The matrix of learning outcomes (Annex 2) should reflect the relationship between courses and learning outcomes.

6.3. To ensure that the educational program provides theoretical and practical content that meets the changing needs of society and the labor market, the syllabi of courses should be regularly updated.

7. Infrastructure and Human Resources

7.1. The teaching, learning, and assessment processes of the Educational Program require the higher education institution to have the following infrastructure:

- Lecture halls equipped with appropriate facilities;
- Computer rooms equipped with modern software and access to the internet;
- Rooms for practical exercises and group work;
- Electronic libraries, scientific databases, and traditional library rooms.

7.2. The academic staff of higher education institutions usually hold scientific degrees. Persons from other state or private institutions and/or relevant organizations may also be involved in teaching.

8. Practical Training (Internship)

8.1. Practical training is important for the application of the student’s theoretical knowledge in practice, as well as for strengthening professional skills.

8.2. Practical training can be organized in private companies, state institutions, research laboratories (including universities, the Azerbaijan National Academy of Sciences (ANAS), private local or international organizations and companies, etc.).

8.3. Before the practical training, a contract must be signed between the higher education institution and the company/institution/laboratory where the training will take place. Additionally, upon the student's individual request, permission may be granted to complete training at other companies/institutions/laboratories relevant to the student’s specialty,

including abroad. The contract should specify the terms, rights and responsibilities of the students, and other necessary details.

8.4. The evaluation of the practical training is carried out based on the student's presentation of a report about the training before a commission. The commission is formed with the participation of specialists from relevant departments of the faculty where the student is enrolled.

9. Employment and Lifelong Learning

9.1. Graduates of this program can work in private organizations, companies, government institutions, research institutes requiring deep knowledge of computer science, laboratories and centers, universities, as well as in fields requiring innovation and other transversal competencies relevant to their specialization.

9.2. The higher education institution should regularly conduct surveys on the employment of the program graduates and publish information about available job vacancies on its website.

9.3. Graduates of the Bachelor's program can continue their education in Master's programs in Computer Science, Mathematics, and other related specialties.

9.4. The knowledge, skills, and approaches acquired during the educational process are the initial prerequisites for graduates to pursue independent lifelong learning.

Approved:

Ministry of Education of the
Republic of Azerbaijan
Deputy Head of the Office,
Head of the Department of Science,
Higher and Secondary Specialized
Education (Signature) _____
"28" July 2020

Chairperson of the Working Group
Preparing the Education Programs
Preparing the Education Programs
for the Natural Sciences Group
(Signature)
_____
"27" July 2020

Appendix 1

Learning Outcomes of the Educational Program and Courses

Program Learning Outcomes (PLOs)
PLO 1 – The student should understand the purpose and objectives of the Computer Science specialty, its connections with other fields, and its prospects. They should have knowledge of the formation, development, and evolution of modern statehood traditions of Azerbaijan and be able to analyze and study the political, ideological, economic, and cultural factors shaping modern Azerbaijani statehood. They should be capable of systematically analyzing Azerbaijan's position and role in the contemporary world. The student should be able to present in Azerbaijani language, and demonstrate skills in oratory, academic, and business writing. They should also have presentation skills, oratory abilities, and proficiency in academic and business writing, both spoken and written, in one foreign language. The student must know the basics of civil defense, the forces and means involved, and have knowledge about public awareness in civil defense.
PLO 2 - The student should have knowledge of the elements of set theory, the concept of the limit of a sequence, differential and integral calculus of single-variable and multivariable functions, numerical and functional series, complex numbers, differentiation and integration of functions of a complex variable, and residue theory. They should understand the Cartesian coordinate system in the plane and space, elements of vector algebra, equations of lines and planes, conic sections and quadratic surfaces, matrices and determinants, systems of linear algebraic equations and their methods of solution, linear transformations, and quadratic forms. The student should know methods for constructing solutions of ordinary differential equations, classification of partial differential equations, the formulation and well-posedness investigation of Cauchy and boundary value problems for mathematical physics equations. They should understand events and operations on them, various definitions of probability and methods for its calculation, distribution laws of discrete and random variables and their numerical characteristics, basic elements of mathematical statistics, statistical estimation for selecting distribution parameters, and laws related to the normal distribution.
PLO 3 – The student should have knowledge of the fundamental concepts of mathematical logic, basics of discrete mathematics, Boolean algebra, minimization of Boolean functions, elements of graph theory, types and properties of graphs, representation of certain problems in graph form, numerical methods of algebra, analysis, differential and integral equations, and construction of solution algorithms for specific problems with the aid of computer technologies. They should understand necessary and sufficient conditions for extrema of single-variable and multivariable functions, conditional extrema and the method of Lagrange multipliers, convex sets, convex functions and their properties, linear and convex programming problems and their solution methods, classical variational problems, elements of optimal control

theory, as well as the laws of physics, their essence, principles of practical application, and use.
PLO 4 – The student should know the main and peripheral devices of a computer, their operating principles, and key characteristics. They should have knowledge about the interaction of computer components and the technical means that ensure this interaction. The student should understand the functions, classification, and components of operating systems (such as MS Windows, Linux, etc.). They should know the concept of processes in operating systems, file systems and their management, as well as tools for allocation and management of RAM among programs. They should be familiar with algorithms, their properties, and representation methods; basic principles and stages of programming; fundamental concepts, operators, methods, and functions of algorithmic languages; how to call these methods and functions; files, their types, and file operations; dynamic data structures; and the basics of programming technology. The student should know modern programming languages (C++, C#, Java, Python, etc.) and be able to independently develop and execute programs in these languages. They must also be capable of developing various algorithms, analyzing their complexity, and estimating the growth rate of algorithms.
PLO 5 – The student should know the structure of information systems, the stages of information system development, methods of organizing databases, data models, database management systems, and query languages. They should be able to apply this knowledge to solve practical problems. The student should have knowledge of the purpose of artificial intelligence, the classification of work carried out in this field, and the main directions of research. They should understand knowledge representation models, including logical models, semantic models, frame models, production models, and object-oriented models.
PLO 6 – The student should have knowledge of computer networks and network operating systems, including network technologies, network models, methods of information exchange in networks, and methods to ensure information security in networks. They should know how to use JavaScript to provide functionality for web pages and be able to coordinate HTML and CSS for more effective web page design. The student should understand parallel computing systems (such as multiprocessor and pipeline systems), the principles and characteristics of parallelization of computations in these systems, and be able to design parallel algorithms for solving various problems. They should know the methods of synchronization (parallelism) of applied processes in distributed systems and mechanisms for fault tolerance. The student must be able to work with algorithms that ensure transactional processing of information and serialization of transactions in distributed systems.

Learning Outcomes (LOs) of the course " History of Azerbaijan":
CLO 1 – Knows the emergence, formation, and development of modern statehood traditions of Azerbaijan.
CLO 2 – Demonstrates knowledge about Azerbaijani statehood in ancient and medieval periods, and during the 15th–18th centuries, including the creation of great Eastern empires by the Azerbaijani people.
CLO 3 – Is able to analyze and study the role of political, ideological, economic, and cultural factors in the formation of modern Azerbaijani statehood.
CLO 4 – Has knowledge of the loss of Azerbaijani statehood in the first decades of the 19th century and its political, economic, and social consequences; the national struggle for statehood in Azerbaijan; the establishment of the Azerbaijan Democratic Republic (first republic period); the second republic; Azerbaijani statehood during the Soviet Empire; the beginning of the independence struggle in the late 1980s; and the restoration of independent statehood.
CLO 5 – Can systematically analyze the place and role of the Azerbaijani state in the modern world.
CLO 6 – Has knowledge about the creation of a secure international environment for the protection of independent statehood, the struggle for restoring the territorial integrity of Azerbaijan, and Azerbaijan’s emergence as a leading state in the Caucasus.

Learning Outcomes (LO) for the Course “Business and Academic Communication in the Azerbaijani Language”
CLO 1 – Knows the history of the Azerbaijani language, its development stages, and ways to enrich it.
CLO 2 – Understands the periods in history when the Azerbaijani language was subjected to pressure and aggression by hostile forces, and recognizes the role of national unity, pride, and the contributions of prominent commanders and statesmen in preserving the language.
CLO 3 – Analyzes scientific information in their field of study in Azerbaijani and prepares both oral and written presentations.
CLO 4 – Demonstrates academic and business public speaking skills in the Azerbaijani language.
CLO 5 – Is able to preserve the uniqueness of the Azerbaijani language, engage with the cultural heritage of other nations through translation, and establish effective communication with them.

CLO 6 – Is capable of advocating for the purity of the Azerbaijani language, protecting it from foreign elements, and ensuring its sustainability and continued usage.

Learning Outcomes (FTN) for the Course “Business and Academic Communication in a Foreign Language”
CLO 1 – Analyzes scientific articles in their field of study written in a foreign language and prepares summaries of them.
CLO 2 – Demonstrates the ability to analyze the grammatical, lexical, and semantic structures of the foreign language.
CLO 3 – Is able to represent and promote their nation’s moral and cultural values and achievements on the international stage.
CLO 4 – Engages in idea and experience exchange in a foreign language and establishes professional communication.
CLO 5 – Develops interpersonal communication skills and the ability to work in a team through foreign language proficiency.
CLO 6 – Presents scientific information in their field of study both orally and in written form in a foreign language.

Course Learning Outcomes (CLO) for “Mathematical Analysis”
CLO 1: Should possess knowledge of the elements of set theory, the concept of the limit of a sequence, the limit and main properties of single-variable functions, continuity of a single-variable function at a point and on a set, and uniform continuity of single-variable functions on a set.
CLO 2: Should know the derivative and differential of a single-variable function, the fundamental theorems of differential calculus, higher-order derivatives and differentials, the Taylor formula for single-variable functions, the necessary and sufficient conditions for extremum, graphing a function based on characteristic points, and the concepts and properties of indefinite, definite, and improper integrals.
CLO 3: Should possess knowledge of the concepts and related theorems of numerical series, functional sequences and series, power series, Taylor and Maclaurin series, and Fourier series.
CLO 4: Should understand the multi-dimensional Euclidean space, the limit, continuity, and uniform continuity of multivariable functions.

CLO 5: Should know the partial derivatives and differentials of multivariable functions, higher-order partial derivatives and differentials, the Taylor formula, and the necessary and sufficient conditions for extremum.
CLO 6: Should acquire knowledge of parameter-dependent integrals, multiple Riemann integrals, line integrals, and surface integrals, and be able to calculate them.

Course Learning Outcomes (CLO) for “Complex Analysis”
CLO 1: Should possess knowledge of the concept of complex numbers, operations with complex numbers, the argument and modulus of a complex number, the trigonometric form of a complex number, Euler's formula, powers and roots of complex numbers, and the extended complex plane.
CLO 2: Should acquire knowledge of functions of a complex variable, their continuity and differentiability, the Cauchy-Riemann equations, the concept of conformal mapping, and regular (analytic) functions.
CLO 3: Should understand the integration of functions of a complex variable, the Cauchy integral theorem, and the Cauchy integral formula.
CLO 4: Should possess knowledge of the Laurent series and its domain of convergence, the classification of isolated singular points of regular functions, and entire and meromorphic functions.
CLO 5: Should know the concept of a residue, the fundamental theorem of residue calculus, and methods of computing residues.
CLO 6: Should be able to compute certain integrals using residues, and should know the argument principle and Rouche's theorem.

Course Learning Outcomes (CLO) for “Analytic Geometry”
CLO 1: Should possess knowledge of the Cartesian coordinate system in the plane and in space, and understand basic problems of analytic geometry.
CLO 2: Should be able to solve systems of linear equations with two and three unknowns.
CLO 3: Should know the elements of vector algebra.
CLO 4: Should acquire knowledge of coordinate transformations and the equations of lines and planes.
CLO 5: Should understand the properties of conic sections of a circular cone.
CLO 6: Should possess knowledge of second-order algebraic curves and surfaces.

Course Learning Outcomes (CLO) for “Linear Algebra”
CLO 1: Should be able to perform operations on polynomials and matrices, understand the properties of determinants, calculate them, and apply Laplace’s theorem.
CLO 2: Should have knowledge of linear spaces and their bases.
CLO 3: Should understand systems of linear algebraic equations, their solution methods, and the Kronecker-Capelli theorem.
CLO 4: Should possess knowledge of Euclidean space and the orthogonalization method.
CLO 5: Should have knowledge of linear and bilinear transformations.
CLO 6: Should understand quadratic forms and their classification.

Learning Outcomes for the Course “Discrete Mathematics” (CLO)
CLO 1: Should know the basic concepts of mathematical logic, axiomatic methods, understand syntax and semantics, and gain experience working with formal languages.
CLO 2: Should have knowledge of the fundamentals of discrete mathematics and its applications in programming.
CLO 3: Should learn the main methods of processing discrete information.
CLO 4: Should know Boolean algebra and minimization of Boolean functions.
CLO 5: Should study the elements of graph theory, types of graphs, their typical properties, representation of certain problems in graph form, and solution methods.
CLO 6: Should acquire knowledge about flows in networks and trees.

Learning outcomes (CLO) for the course "Differential Equations"
CLO 1: Should have knowledge of first-order ordinary differential equations and systems, methods for constructing solutions of nth-order ordinary differential equations, and the

investigation of existence, uniqueness, and stability of solutions for Cauchy and boundary value problems for these equations.
CLO 2: Should be able to apply ordinary differential equations to the mathematical modeling of various processes in natural sciences.
CLO 3: Should know the classification of partial differential equations and the derivation of mathematical physics equations representing various natural science processes.
CLO 4: Should understand the formulation of Cauchy and boundary value problems for mathematical physics equations, types of boundary conditions, and their physical interpretation.
CLO 5: Should study the investigation of the well-posedness (correctness) of Cauchy and boundary value problems for mathematical physics equations.
CLO 6: Should have knowledge of methods for solving Cauchy problems for hyperbolic and parabolic type equations, as well as elements of harmonic functions and potential theory.

Learning outcomes (FTN) for the "Probability Theory and Mathematical Statistics"
CLO 1 – Should know events and operations on them, various definitions of probability, and methods for calculating probability.
CLO 2 – Should understand the application of the total probability theorem and Bayes' formula, Bernoulli scheme for sequential repeated trials, and the applications of the Moivre-Laplace and Poisson theorems.
CLO 3 – Should have knowledge of the distribution laws of discrete and random variables and their numerical characteristics.
CLO 4 – Should understand the essence of the law of large numbers and the central limit theorem.
CLO 5 – Should know the basic elements of mathematical statistics, statistical estimation of distribution parameters, and laws related to the normal distribution.
CLO 6 – Should be familiar with statistical parameter estimation, construction of confidence intervals, and methods for testing statistical hypotheses.

Learning outcomes (CLO) for the "Numerical Methods"
CLO 1 – Should have knowledge of function approximation methods, Lagrange and Newton interpolation polynomials, and the calculation of their errors, numerical differentiation and integration methods, as well as the estimation of their errors.

CLO 2 – Should learn numerical solution methods for systems of linear algebraic equations, their assembly, and error estimation; methods for determining roots of nonlinear equations and nonlinear systems, including simple iteration, bisection, Newton, and secant methods.
CLO 3 – Should know numerical methods for solving the Cauchy problem for ordinary differential equations and systems of equations.
CLO 4 – Should be familiar with numerical methods for solving boundary value problems for ordinary and partial differential equations.
CLO 5 – Should know numerical methods for solving integral equations.
CLO 6 – Should understand the application of numerical methods to formulate solution algorithms for specific problems using computer technologies.

Learning Outcomes (FTN) for the course "Optimization Methods"
CLO 1 – Should have knowledge of the necessary and sufficient conditions for the extremum of single-variable and multivariable functions.
CLO 2 – Should understand conditional extremum and Lagrange's method of undetermined multipliers.
CLO 3 – Should know convex sets, convex functions and their properties, linear and convex programming problems and their solution methods, as well as the Kuhn-Tucker theorem.
CLO 4 – Should study the gradient method and penalty function method.
CLO 5 – Should be familiar with classical variational problems, Euler's equation, the second variation of a functional, and the Legendre condition.
CLO 6 – Should have knowledge of elements of optimal control theory, Pontryagin’s maximum principle, and its discrete analogue.

Learning outcomes (FTN) for the course "Computer Networks"
CLO 1 – Should have knowledge of the basic concepts of computer networks, their purposes and classifications, as well as hardware and software of local and wide area networks, and be able to operate in computer networks.
CLO 2 – Should know the topologies of computer networks, various communication lines used for data transmission, and be able to set up a computer network.

CLO 3 – Should understand different network models, including the layers and working principles of the ISO-OSI model.
CLO 4 – Should know the working principles of various network technologies, including client-server technology.
CLO 5 – Should have knowledge about Internet network services and protocols, domain names, and the basic TCP/IP protocol.
CLO 6 – Should be able to operate in Internet search systems and social networks.

Learning outcomes (FTN) for the course "Computer Architecture"
CLO 1 - Should know the stages of computer development and the von Neumann architecture.
CLO 2 - Should know the main components of computers (central processor and main memory), their operating principles, and key characteristics.
CLO 3 - Should have knowledge about the interaction between computer components and the technical means that ensure this interaction (concepts of bus, controller, and driver).
CLO 4 - Should know the computer peripheral devices (external memory, monitor, printers, keyboard, mouse, etc.), their operating principles, and main characteristics.
CLO 5 - Should be able to compare different computers according to their technical specifications.
CLO 6 - Should be able to determine the configuration of a computer that meets the parameters required for a given task.

"Web Technologies" course learning outcomes (CLO)
CLO 1 – Should know the rules of using the HTML language to build the structure of web pages.
CLO 2 – Should know the methods of using CSS to apply design and effects to web pages.
CLO 3 – Should be able to integrate HTML and CSS for more effective web page design.
CLO 4 – Should have a general understanding of ASP.NET, PHP, and their overall structure.
CLO 5 - Should be able to create and integrate various styles using CSS and HTML.
FTN 6 -Should know the methods of using JavaScript to add functionality to web pages.

"Programming Technologies" course learning outcomes (LOs):
CLO 1 – Has knowledge of technologies for the development of large software projects, covering all stages from problem formulation to deployment and operation.
CLO 2 – Understands the types of software quality control and methods of software configuration management.
CLO 3 – Possesses knowledge of creating reliable software tools using modern programming technologies and methods for information security.
CLO 4 – Has knowledge of program structure design and modular programming.
CLO 5 – Understands structured programming and object-oriented programming technologies.
CLO 6 – Knows the classification, detection, and debugging methods of errors, as well as structural and functional testing techniques.

Learning Outcomes (LO) for the "Parallel and Distributed Computing" Course
CLO 1 – Must have knowledge of parallel computing systems (multiprocessor and pipeline-type systems), understand the principles and characteristics of computation parallelization in these systems, and be able to design parallel algorithms for solving various problems.
CLO 2 – Should be able to manage resource processing in single- and multiprocessor systems, understand node critical state transitions, and work with algorithms for mutual cancellation of concurrently executed processes.
CLO 3 – Must know synchronization (parallelism) methods of application processes in distributed systems and mechanisms for fault tolerance.
CLO 4 – Should be able to work with algorithms ensuring transactional processing and serializability of transactions in distributed systems.
CLO 5 – Must understand Lamport timestamps and their operating principles, queueing of transactions according to their timestamps, the principle of aborting delayed transactions, and the operation of the modified timestamp algorithm designed to reduce the number of aborted transactions.
CLO 6 – Should know the blocking mechanism, two-phase locking, deadlock, resources and resource queues, transaction execution and aborting, and be able to write results to the database.

Learning outcomes (CLO) for the course "Operating Systems":

CLO 1 – Should know the functions, classification, and components of operating systems.
CLO 2 – Must understand the concept of processes in operating systems, the file system, and their management.
CLO 3 – Should know the methods of allocation and management of the main memory among programs, as well as the management of peripheral devices.
CLO 4 – Must have knowledge about the working principles of service programs in operating systems families such as MS Windows, Linux, etc.
CLO 5 – Should be able to operate the MS Windows system and configure it for a specific user.
CLO 6 – Must be able to diagnose malfunctions in the MS Windows system and eliminate some of these issues.

Learning outcomes (FTN) for the course "Methods of Algorithm Analysis and Design":
CLO 1 – Should know the mathematical foundations of algorithm analysis, methods for analyzing algorithms in the best, worst, and average cases; search and sorting algorithms (sequential search, binary search, etc.) and their analysis.
CLO 2 – Must be able to develop and analyze algorithms for operations on data structures (stack, list, tree), understand relations and their solution methods.
CLO 3 – Should know the main classes of algorithms, including algorithms related to dynamic programming.
CLO 4 – Must be able to estimate algorithmic complexity; apply breadth-first and depth-first search algorithms to solve concrete problems and evaluate their complexity.
CLO 5 – Should be able to write pseudocode for search and sorting algorithms and analyze them.
CLO 6 – Must have skills in finding optimal algorithms and solving simple recurrence relations; know the methods of developing "greedy" algorithms, their application, and complexity evaluation.

Learning outcomes (FTN) for the course "Fundamentals of Programming"
CLO 1 – Should understand the subject, components of computer science, and operations on numbers in various numeral systems.
CLO 2 – Must know the basic operating principles of computers and the characteristics of data representation in memory.

CLO 3 – Should know the basic elements of algorithmization; tools for programming linear, branching, and loop algorithms.
CLO 4 – Must be able to develop linear programs and program branching and loop processes.
CLO 5 – Should understand the characteristics of working with static and dynamic arrays and the organization of file operations.
CLO 6 – Should be able to solve various problems using helper functions, standard libraries, dynamic variables, and be proficient in solving problems related to queues, stacks, deques, and lists.

"Database" course learning outcomes (CLO):
CLO 1 – Should know the basic concepts of information systems, the processes occurring in information systems, the development stages of information systems, and their application areas.
CLO 2 – Should know the structure of information systems and the stages of information system development.
CLO 3 – Should know operations on relational data, normalization forms, and how to choose an algorithm to bring a problem into normal form in the relational model.
CLO 4 – Should know the concepts of databases, methods of database organization, and data models.
CLO 5 – Should know database management systems, query languages, and be able to apply them to solve practical problems.
CLO 6 – Should have the ability to define a task for creating an automated information system for any subject area, select an appropriate model for the given task, and create databases in SQL or Oracle.

Artificial Intelligence course learning outcomes (CLO)
CLO 1 – Should have knowledge of the purpose of the emergence of artificial intelligence, the classification of work conducted in this field, and the main directions of its research.
CLO 2 – Should know about artificial intelligent systems, knowledge representation, classification of knowledge, the logical model of knowledge representation, and problems related to knowledge acquisition.
CLO 3 – Should have knowledge about knowledge and knowledge bases, as well as the characteristics that define knowledge.

CLO 4 – Should know the models for knowledge representation: logical models, semantic models, frame models, production models, and object-oriented models.
CLO 5 – Should know the classification of expert systems, the technologies for their development, and their application areas.
CLO 6 – Should know the methods and strategies for solution search in expert systems, as well as logical inference mechanisms.

Learning Outcomes (CLO) for the subject "Physics"
CLO 1 – Should know the fundamental laws of classical mechanics and the basic elements of the theory of relativity.
CLO 2 – Should understand the main laws and regularities of molecular physics, thermodynamics, and electrodynamics.
CLO 3 – Should have knowledge of wave optics.
CLO 4 – Should know the fundamental laws and regularities of quantum physics, atomic and nuclear physics.
CLO 5 – Should be familiar with the mathematical expressions of the basic laws of physics.
CLO 6 – Should be able to perform certain experimental procedures, evaluate results in laboratory work, and calculate errors.

Learning Outcomes (CLO) for the subject "Civil Defense"
CLO 1 – Should know the basics, forces, and means of civil defense.
CLO 2 – Should be familiar with emergencies and their characteristics.
CLO 3 – Should possess knowledge about population protection during emergencies and public awareness in civil defense.
CLO 4 – Should be able to use individual and collective protective equipment.
CLO 5 – Should know the basics of industrial facility operational stability during emergencies and its assessment.
CLO 6 – Should have knowledge about organizing and implementing the elimination of consequences of emergencies.

Appendix 2

Matrix of Courses and Learning Outcomes of the Educational Program

		Program Learning Outcomes					
Block Name	Course Names	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6
General Courses	Azerbaijani History	X					
	Business and Academic Communication in Azerbaijani	X					
	Business and Academic Communication in a Foreign Language	X					
	Elective Courses	X					
Specialized Courses	Mathematical Analysis		X				
	Complex Analysis		X				
	Analytical Geometry		X				
	Linear Algebra		X				
	Discrete Mathematics			X			
	Differential Equations		X				
	Probability Theory and Mathematical Statistics		X				
	Numerical Methods			X			
	Optimization Methods			X			
	Fundamentals of Programming				X		
	Methods of Algorithm Analysis and Design				X		
	Programming Technologies				X		
	Database Systems					X	

	Computer Architecture				X		
	Computer Networks						X
	Web Technologies						X
	Parallel and Distributed Computing						X
	Artificial Intelligence					X	
	Operating Systems				X		
	Physics			X			
	Civil Defense	X					