Ministry of Education and Science of Ukraine
V. N. Karazin Kharkiv National University

APPROVE

Deputy Chairman of the Admissions Committee,
Vice-Rector for Scientific and Pedagogical Work
V. N. Karazin Kharkiv National University

_____ Oleksandr HOLOVKO

PROGRAM
Computer Science Professional Exam to obtain an educational degreeMASTER by specialty F3 Computer Science (educational and professional program "Informatics")

Kharkiv 2025

Exam program

No.,s/n		Specific gravity, %	Level
1	**ALGORITHMS AND COMPUTATIONAL COMPLEXITY**	**20**	
1.1	Data Structure Basics and Algorithms		
1.1.1	The concept of an algorithm. Determining its time and space (in terms of memory) complexity		IN
1.1.2	The concept of an abstract data type. Abstract data types: stacks, lists, vectors, dictionaries, sets, multisets, queues, priority queues		IN
1.1.3	Tuples, sets, dictionaries, singly and doubly linked lists. Implementation of abstract data types with evaluation of the complexity of operations		IN
1.1.4	Basic algorithms and their complexity: searching, sorting (simple selection, insertion, swap and advanced tree sorts, Shell sort, quick sort)		IN
1.1.5	Algorithms on graphs and their complexity: breadth-first and depth-first search; search for connected components; construction of a spanning tree; construction of shortest paths from a selected vertex; construction of shortest paths between two vertices		IN
1.2	Computational models		
1.2.1	Imperative and declarative approaches to programming.		IN
2	**COMPUTER SYSTEM ARCHITECTURE**	**10**	
2.1	Binary logic functions		IN
2.2	Machine-level data representation		
2.2.1	Positional number systems. Binary, octal, hexadecimal number systems. Unsigned integer code. Complementary integer code. Basic arithmetic operations on integers in unsigned and complement codes.		IN
2.2.2	Principles of representing real numbers in program memory in floating-point format. Advantages and disadvantages of floating-point number formats. Basic arithmetic operations on real numbers in floating-point format and their problems.		IN
2.3	Functional organization of computer systems		
2.3.1	Computer structure, classical von Neumann architecture, Harvard architecture.		AND
3	**DATABASES AND DATA WAREHOUSES**	**20**	

3.1	Keys and data normalization: basic normal forms (1NF, 2NF, 3NF, BCNF)		IN
3.2	Basic concepts of database systems: data model; query language; transaction; ACID transaction properties, indexing; backup and recovery; data distribution and replication; data security		IN
3.3	Data modeling: creating a data model for an information system; conceptual, logical, physical data models; ER model; ER model notations		WITH
3.4	Relational databases: features of data organization and storage in relational databases; main characteristics of relational databases; DBMS (Database Management System)		IN
3.5	Query construction: SQL (structured query language), DDL (Data Definition Language), DML (Data Manipulation Language), DCL (Data Control Language), TCL (Transaction Control Language) languages		WITH
3.6	Query processing: basic operations of relational algebra: selection, projection, union, intersection, difference, cartesian product, join by attribute, division		WITH
4.	**SYSTEMS AND SOFTWARE ENGINEERING**	**10**	
4.1	Information systems		
4.1.1	Concept, goals, meaning, classification by functionality, scale, scope		B
4.1.2	Providing information systems: organizational, informational, mathematical, software, technical, linguistic, methodological, legal		B
4.2	Requirements analysis		
4.2.1	Classification of software requirements. sources and methods of requirements gathering;		B
4.2.2	User requirements (use cases and user stories)		B
4.2.3	Functional and non-functional requirements, constraints; structuring of functional requirements.		B
4.3	Software design		
4.3.1	Types of design: Structural DesignObject-Oriented DesignFunctional DesignArchitectural DesignInterface Design		IN
4.3.2	Design paradigms: top-down functional decomposition, data-driven architecture, object-oriented analysis and design, event-driven architecture.		IN

4.3.3	Identification of domain classes. UML class hierarchy diagrams: modeling subsystems, classes, and relationships between them.		WITH
4.3.4	Designing use case implementation scenarios based on UML sequence and communication diagrams.		WITH
4.3.5	Basic design patterns: MVC, Abstract Factory, Facade, Decorator, Flyweight, Visitor, Observer, Proxy, Strategy, Chain of Responsibility).		IN
4.4	Software implementation		
4.4.1	Requirements for code design: style, division into structured units, naming of variables, classes, objects.		IN
4.4.2	Tools for automatic code generation		IN
4.4.3	Debugging: Breakpoints, Variable Watch, Console Output, Debugger, Code Analyzers.		B
4.4.4	Software configuration and version management.		B
4.4.5	Continuous Integration/Continuous Delivery.		IN
4.5	Quality assurance: commonalities and differences between testing, verification, and validation processes		
4.5.1	White and black box testing.		WITH
4.5.2	Testing levels: modular, integration, system, validation.		B
4.5.3	Test-driven development.		IN
4.5.4	Additional verification and validation techniques: code inspection, standards and requirements compliance testing, usability and user experience evaluation, performance and scalability testing.		IN
4.6	Teamwork, approaches to software development (SW)		
4.6.1	Classic software development models: cascade (waterfall), iterative, incremental.		B
4.6.2	Industrial software development technologies: RUP, MSF, Agile, Scrum, Extreme Programming (XP), Kanban.		B
4.6.3	Roles and responsibilities in the project team, the benefits of teamwork, the risks and complexity of such cooperation.		B
4.6.4	The main stages of planning and implementing an IT project. The IT project life cycle.		B
5	**MATHEMATICS IN IT**	**20**	
5.1	Application of methods of mathematical analysis, analytical geometry, linear algebra in IT		
5.1.1	Numerical sequence and its limit. Infinitely small and large		IN

	quantities. Comparison of infinitely small and large quantities.		
5.1.2	Derivative and its application to the study of functions of one variable.		B
5.1.3	Calculation of definite integrals (method of rectangles, method of trapezoids).		IN
5.1.4	Applications of functions of many variables. Partial derivatives. Necessary and sufficient conditions for an extremum.		IN
5.1.5	Optimization methods: Basic concepts and objectives in linear and nonlinear programming problems. Gradient descent method: idea and algorithm.		IN
5.1.6	Data approximation. Least squares method (linear dependence).		WITH
5.1.7	Number series and the concept of their convergence. Power series.		IN
5.1.8	Basic definitions of the theory of differential equations: order of a differential equation, partial solution, general solution, Cauchy problem. Concept of iterative methods for their solution.		IN
5.1.9	Line and plane in space. The concept of hyperplane. Curves and surfaces of the second order. Ellipse, hyperbola, parabola.		B
5.1.10	Matrices and matrix operations. Determinants. Inverse matrix.		IN
5.1.11	Eigenvectors and eigenvalues of a matrix.		IN
5.1.12	Systems of linear algebraic equations, conditions for their solvability. Numerical methods for their solution.		B
5.1.12	Linear vector space and its basic properties. Dimension and basis of space.		AND
5.2	Discrete mathematics		
5.2.1	The concept of a set. Operations on sets: union, intersection, difference, addition, Boolean set, Cartesian product.		WITH
5.2.2	Binary relations and their properties: reflexivity, symmetry, transitivity.		IN
5.2.3	Combinatorial analysis. Sum and product rule. Combinations, permutations, placement: without repetitions and with repetitions. Principle of inclusions and exclusions.		IN
5.2.4	Elements of mathematical logic. Logical conjunctions. Truth tables. Boolean functions. Forms of representation of Boolean functions. Logic of statements.		IN
5.2.5	Graphs. Types of graphs: Directed and undirected graphs. Vertices and edges, vertex degree, adjacency. Isomorphism of graphs. Operations on graphs: union, direct sum, addition, edge		IN

	deletion, vertex deletion.		
5.2.6	Routes, chains, cycles and their varieties in graphs.		IN
5.2.7	Graph connectivity, components of connectivity of undirected graphs. Distance between vertices.		IN
5.2.8	Trees, forests: basic concepts.		IN
5.3	Application of probability theory and mathematical statistics in IT		
5.3.1	Stochastic experiment. Space of elementary events. Operations on events. Combinatorial and geometric probability. Conditional probability.		IN
5.3.2	Total probability formula. Bayes' formula. Bernoulli's independent trials scheme. Law of large numbers.		IN
5.3.3	Numerical characteristics of one-dimensional random variables (mathematical expectation, mean, median, and variance).		IN
5.3.4	The concept of distribution of a random variable. Distribution function. Density distribution. Uniform and normal distributions.		IN
5.3.5	The concept of statistical relationship. Linear and logistic regression. Pairwise correlation coefficient.		IN
5.3.6	Multidimensional discrete quantities. The concept of a joint distribution. Correlation matrix.		AND
5.3.7	The concept of a random function and a random process.		AND
5.3.8	Basic tasks of mathematical statistics. Primary data processing.		IN
5.3.9	Data visualization (scatter chart, histogram, bar chart, pie chart).		WITH
5.3.10	Point and interval estimates of the characteristics of random variables. Confidence intervals.		IN
5.3.11	Basic concepts and testing of statistical hypotheses (null hypothesis, alternative hypothesis, significance level, homogeneity of normally distributed samples).		IN
6	**BASICS OF PROGRAMMING LANGUAGES**	**20**	
6.1	The essence and types of programming languages		
6.1.1	The concept of class and object in object-oriented programming; constructor and destructor, interface and implementation.		IN
6.1.2	Basic concepts of object-oriented programming: abstraction, encapsulation, inheritance, polymorphism.		B
6.1.3	Relationships between classes in object-oriented programming: association, aggregation, composition, inheritance,		WITH

	dependency, implementation.		
6.1.4	Comparison of procedural and object-oriented programming.		B
6.2	Principles and scope of programming types: functional, logical, event-driven, reactive, generalized programming		IN
6.3	Parallel computing models: Flynn classification		B
6.4	Translation and execution: compiler, interpreter, linker		B

*Cognitive levels of coverage: Level A. Required cognitive level "Knowledge". Level B. Required qualification level "Knowledge", "Understanding". Level C. Required qualification level "Knowledge", "Understanding", "Application". Level D. Required qualification level "Knowledge", "Understanding", "Application" and "Analysis"/"Synthesis"/"Evaluation".

List of recommended readings

1. Andriychuk V. I., Zabava B. V. Linear Algebra. – Lviv: LNU, 2008.
2. Borysenko O.A., Ushakova L.M. Analytical Geometry. – Kharkiv: Osnova, 1993.
3. Dorogovtsev A. Ya. Mathematical Analysis. Parts 1-2. – Kyiv: Lybid, 1993, 1994.
4. Zabolotskyi M.V., Storozh O. G., Tarasyuk S. I. Mathematical Analysis. — Kyiv: Znannia, 2008.
5. Samoilenko A. M., Kryvosheya S. A., Perestyuk M. O. Differential equations in examples and problems. – Kyiv: Higher School, 1994.
6. Gnedenko B. V. Course in Probability Theory. – Kyiv: VPC “Kyiv University”, 2010.
7. Holomozy V.V., Kartashov M.V., Ralchenko K.V. Collection of problems on probability theory and mathematical statistics: textbook – Kyiv: Kyiv University, 2015.
8. Bondarenko M.F., Bilous N.V., Rutkas A.G. Computer Discrete Mathematics. – Kharkiv: “SMIT Company”, 2004.
9. Cormen, Thomas H.; Leiserson, Charles E.; Rivest, Ronald L. Introduction to Algorithms. - 1 st. - MIT Press and McGraw-Hill, 1990. - ISBN 0-262-03141-8.
10. Cormen, Thomas H.; Leiserson, Charles E.; Rivest, Ronald L.; Stein, Clifford. Introduction to Algorithms. - 3rd. - MIT Press, 2009. - ISBN 0-262-03384-4.
11. Sedgewick, Robert; Wayne, Kevin (2011). Algorithms (4th ed.). Addison-Wesley Professional. ISBN 978-0-321-57351-3.
12. Flajolet, Philippe; Sedgewick, Robert (1995). An Introduction to the Analysis of Algorithms. Addison-Wesley. ISBN 978-0-201-40009-0.
13. Niklaus Wirth. Algorithms & Data Structures. Prentice-Hall, 1986. [PDF (2353 KB)] ISBN 0-13-022005-1
14. Donald E. Knuth, The Art of Computer Programming. Vol. 1:

Fundamental Algorithms (3rd ed.). Addison-Wesley Professional. (1997). ISBN 978-0-201-89683-1.

15. Donald E. Knuth, The Art of Computer Programming. Vol. 2: Seminumerical Algorithms (3rd ed.). Addison-Wesley Professional. (1997). ISBN 978-0-201-89684-8.

16. The Art of Computer Programming. Vol. 3: Sorting and Searching (2nd ed.). Addison-Wesley Professional. (1998). ISBN 978-0-201-89685-5.

17. Donald E. Knuth, The Art of Computer Programming. Vol. 4A: Combinatorial Algorithms, Part 1. Addison-Wesley Professional. (2011). ISBN 978-0-201-03804-0.

18. The Art of Computer Programming. Vol. 4B: Combinatorial Algorithms, Part 2. Addison-Wesley Professional. (2022). ISBN 978-0-201-03806-4.

19. Stroustrup, Bjarne (2013). The C++ Programming Language (Fourth ed.). Addison-Wesley. ISBN 978-0-321-56384-2.

20. Stroustrup, Bjarne (1994). The Design and Evolution of C++. Addison-Wesley. ISBN 0-201-54330-3. B. Stroustrup. The C++ Programming Language (1st, 2nd, 3rd, and 4th edition).

21. Herb Schildt's Java Programming Cookbook (ISBN 0-07-226315-6, Osborne/McGraw Hill, 2007).

22. Herb Schildt's C++ Programming Cookbook (ISBN 0-07-148860-X, Osborne/McGraw Hill, 2008).

23. Barbara Liskov with John Guttag (2000). Program Development in Java - Abstraction, Specification, and Object-Oriented Design. USA, Addison Wesley. ISBN 9780201657685.

24. Gosling, James; Joy, Bill; Steele, Guy L. Jr.; Bracha, Gilad (2005). The Java Language Specification (3rd ed.). Addison-Wesley. ISBN 0-321-24678-0. Archived from the original on February 14, 2012. Retrieved February 8, 2019.

25. Database organization: practical course: Textbook for students / A. Yu. Berko, O. M. Veres; National University "Lviv. Polytechnic". – L., 2003. – 149 p.

26. Date, CJ Date on Database: Writings 2000–2006. - Apress, 2006. - 566 p. – ISBN 978-1-59059-746-0, 1-59059-746-X.

27. Date, CJ Database in Depth. - O'Reilly, 2005. - 240 p. - ISBN 0-596-10012-4.

28. Beynon-Davies P. (2004). Database Systems 3rd Edition. Palgrave, Basingstoke, UK. ISBN 1-4039-1601-2

Test structure

The test consists of 50 closed-ended test questions with four answer options in the proposed sections:

No. of employees/ employees	Section name	The number of closed-ended test questions by section that will be offered to the applicant from the general base of test questions
1.	ALGORITHMS AND COMPUTATIONAL COMPLEXITY	10
2.	COMPUTER SYSTEM ARCHITECTURE	5
3.	DATABASES AND DATA WAREHOUSES	10
4.	SYSTEMS AND SOFTWARE ENGINEERING	5
5.	MATHEMATICS IN IT	10
6.	BASICS OF PROGRAMMING LANGUAGES	10

In the case of conducting the exam remotely, the LMS platform "Moodle" is used with applicant authentication in the video conference mode. Registration (admission to take the exam) of participants in the educational process, as well as the exchange of control (final) tasks and answers to them is carried out exclusively from the e-mail address specified in the application for admission, ensuring academic integrity. When conducting the exam remotely, technical and software tools are used that allow audio and video recording.

Evaluation criteria

The correct answer is worth 4 points.

The maximum score for completing all tasks is 200 points.

The minimum number of points for admission to participation in the competitive selection is 100 points.

Head of the certification committee Svitlana IGNATOVYCH

Meeting of the admissions committee dated "_20_" _March_ 2025, minutes No._2_.

Responsible Secretary of the Admissions Committee Hanna ZUBENKO