

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
SUMY STATE UNIVERSITY



APPROVED BY

Head of the Admissions Committee

20 23

**PROGRAM**  
**of the entrance examination for admission to study for the Master's degree**  
**in the specialty 122 Computer Science**

**GENERAL PROVISIONS**

The program covers issues related to mathematical methods and algorithmic principles in modeling, design, development, and maintenance of information technologies. It is on these issues that the candidate for admission can demonstrate the corresponding level of theoretical knowledge and practical skills in solving specialized problems in the field of computer science.

The fundamental disciplines are "Discrete Mathematics," "Algorithms and Data Structures," "Programming," "Mathematical Methods of Operations Research," "Databases and Information Systems," "Web Programming and Web Design."

All of the listed disciplines are profiled to solve scientific and applied problems related to calculations and design of information systems.

The entrance examination is conducted in the form of a written test. The structure of the exam tasks (test) will be provided below.

Two academic hours (80 minutes) are allotted for completing the tasks.

**ANNOTATIONS AND KEY QUESTIONS**  
**FOR DISCIPLINES INCLUDED IN THE EXAM**

**Discipline: "Discrete Mathematics"**

Sets, operations on sets. Relations, operations on relations. Equivalence and order relations. Elementary Boolean functions, function composition. Tabular method for defining functions. Canonical forms of Boolean functions, methods for constructing canonical forms. Zhegalkin algebra, methods for constructing Zhegalkin polynomials. Minimization of Boolean functions. Graphs, methods for defining graphs. Paths in graphs, connected graphs. Eulerian graphs. Automata theory, minimization of automata, partial automata.

References: [1-3]

**Discipline "Algorithms and Data Structures"**

Definition of abstract data types. Data types, data structures. Basic ways of representing data structures. Classification of data structures. Basic methods and paradigms of algorithm theory. Basic definitions and properties of algorithms. The principle of greedy choice and its implementation in algorithms. The "divide and conquer" principle and its implementation in algorithms. Insertion sort and its implementation. Merge sort and its implementation. Heap sort and its implementation. Quick sort and its implementation. Binary trees, search procedure. Improved sorting methods. Binary trees, insertion procedure. Binary trees, deletion procedure. Kruskal's algorithm for constructing a minimum spanning tree of a graph. Prim's algorithm for constructing a minimum spanning tree of a graph. The problem of maximum flow in graphs and algorithms for its solution. Analysis of algorithms, asymptotic notation, running time. Red-black trees and their properties. Complexity classes of algorithms, relationships between classes. Algorithms for finding shortest paths in a graph. Huffman codes. Greedy algorithms and their applications: Huffman encoding, construction of minimum spanning trees of a graph. Dynamic programming and its applications.

References: [4-6].

**Discipline "Programming"**

The main features of developing object-oriented programs using C++. Basic concepts of a class. Concepts of constructors and destructors. Features of implementing the mechanism of accessing class

members. Classes and structures. Classes and unions. Built-in functions. Arrays of objects. Pointers to objects. Organization of classes and features of working with objects. Friend functions. Passing and returning objects to functions. The concept of the "this" keyword. Features of the mechanism for overloading operators. Organization of the inheritance mechanism in classes. The concept of virtual functions and polymorphism. Working with template functions and classes. Exception handling mechanisms. Organization of input and output systems in C++. The concept of namespaces.

References: [10-12]

### **Discipline "Mathematical Methods of Operations Research"**

Basic concepts and definitions of Operations Research. Methodology of Operations Research. Typical classes of Operations Research problems. Linear programming. Duality. Examples of linear programming problems. Resource allocation problem, cutting stock problem, transportation problem. Forms of linear programming problems. Simplex method for solving linear programming problems. Duality. Post-optimization analysis. Nonlinear programming. General nonlinear programming problem. Classical extremum conditions. Numerical methods in nonlinear programming problems. Direct search method (Hooke-Jeeves method), deformable polyhedron method, Nelder-Mead method. Solving problems with constraints. Lagrangian multiplier method. Gradient methods for solving nonlinear programming problems. Lagrangian multiplier method. Dynamic programming. Basic concepts of dynamic programming. Bellman's principle of optimality. Resource allocation problem. Optimization methods for non-differentiable functions. Interval methods. Dichotomy method, Fibonacci method, golden section method. Optimization methods for differentiable functions. Quadratic interpolation method, polynomial interpolation method, Newton's method, fastest descent method. Discrete and stochastic programming. Principles of discrete programming. Branch-and-bound method for solving integer linear programming problems. General characteristics of discrete problems. Formulation of stochastic programming problems. Methods for solving stochastic programming problems. Branch and bound method.

References: [7-9]

### **Discipline: "Databases and Information Systems"**

Database design: modeling examples using IDF0 and DFD methodologies. Relational database model: functional dependencies, Codd's reduction algorithm, normal forms. Integrity of entities and references. Design of logical data organization: content, terms, and examples of the DFD and ERD standards. Basics of SQL language: data manipulation commands (DML), data control commands (DDL).

References: [13-15]

### **Discipline: "Web Programming and Web Design"**

Особливості HTML5. Синтаксис. Структура HTML-документа. Основні елементи. Рядкові і Features of HTML5. Syntax. Structure of an HTML document. Basic elements. Inline and block elements. Document Object Model (DOM). Cascading Style Sheets (CSS3).

Syntax and application of CSS. Selectors. Pseudo-classes, pseudo-elements. Box model. Cascading. Preprocessors SASS, LESS. Client-side programming language JavaScript. Main areas of using JavaScript. Event handlers. Objects and methods. Creating JavaScript functions. Data types of PHP programming language. Operations and expressions of PHP programming language: arithmetic operations, relational operations, logical operations, concatenation and repetition operations, complex assignment operations, selection operations, input operations, here-document operation, Built-in variables. Operators: modifiers of simple operators; modifiers while, until; modifier foreach; compound operators; branching operators; while, until loop operators; for, foreach loops; loop control commands. Regular expressions: metacharacters; metasequences; regular expression operations; search operation; replacement operation; transliteration operation. Subroutines and functions: defining subroutines and calling subroutines; local variables in subroutines. Web programming: HyperText Transfer Protocol; access methods GET, HEAD, POST, PUT; script concept; query types; environment variables; processing HTML form data.

References: [16-18]

## STRUCTURE OF EXAMINATION TASKS

Each written test contains 30 questions (5 questions from each discipline) that require the applicant to demonstrate a sufficient level of theoretical knowledge acquired during the study of the specialized subject, as well as the ability to apply this knowledge in practice. Each question has 4 answer options, of which only one is correct.

The duration of the exam is 2 academic hours (80 minutes).

The exam is conducted according to the following procedure. The applicant receives a tests with specified questions. The questions are formulated in such a way that the applicant does not need to use reference literature or computer equipment to answer them. The applicant answers the questions and records their answers on an answer sheet of a specified pattern.

Examples of the test paper and answer sheet are provided in Appendices A and B, respectively.

## CRITERIA FOR EVALUATING ANSWERS

### General requirements

The commission evaluates the written answers of the applicant to the test tasks on a 100–200-point scale. Applicants who score less than 100 points receive a grade of "unsatisfactory" and are not admitted to further participation in the competitive selection. Applicants who score 100 or more points are allowed to participate in the competitive selection. To receive a positive evaluation from the entrance examination, the applicant must pass the minimum allowable test threshold at the level of 0.17 or 17% of the total test score. For each correct answer to a task, test scores are accrued, and for an incorrect answer, 0 points are accrued. The obtained test scores for the entrance examination are converted to a 100–200-point scale (rounded to the nearest whole number, according to the rules of mathematical rounding) using the following algorithm:

$$O = O_{min} + k \cdot (N - r \cdot T), \text{ where}$$

- $O$  – a score on the entrance exam on a 100–200 point scale;
- $O_{min}$  – the minimum score on the 100–200-point scale for the entrance exam, at which the applicant is admitted to the competitive selection;
- $k$  – the coefficient for converting test scores to the 100–200-point scale, with the following conditions:

$$k = 100 / (T \cdot (1 - r));$$

- $r$  – the minimum allowable test threshold with an accuracy of 0.01, which is set within the range of 0 to 1, but not less than 0.10;
- $T$  – the total number of test scores that an applicant can receive during the entrance examination;
- $N$  – the number of test scores obtained by the applicant during the entrance examination.

If the number of test scores obtained by an applicant during the entrance exam ( $N$ ) is "0", the applicant receives a grade of "unsatisfactory" and is not allowed to participate further in the competitive selection.

### Accrual of test scores

For each correct answer to a test question, 4 test scores are credited. An incorrect answer results in 0 points.

The total number of test scores ( $T$ ) that an applicant can obtain during the entrance exam is 120 test scores.

The number of test scores for the entrance exam ( $N$ ) is calculated as the sum of test scores excluding the test scores deducted for corrections made on the answer sheet (if provided by the program).

### Correction policy:

For each correction made, 1 test score is deducted from the total number of test scores ( $T$ ) that an applicant can obtain during the entrance exam.



## REFERENCES

### Discipline: "Discrete Mathematics"

1. Jon Pierre Fortney. Discrete Mathematics for Computer Science. – CRC Press, 2020. – 270 p.
2. Lewis H., Zax R. Essential discrete mathematics for computer science. – Princeton University Press, 2019. – 403 p.
3. Rosen K. H. Discrete mathematics and its applications. – McGraw-Hill, 2019. – 1118 p.

### Discipline "Algorithms and Data Structures"

4. Cormen T. H., Leiserson C. E., Rivest R. L., Stein C. Introduction to Algorithms. – The MIT Press, 2022. – 1213 p.
5. Vijayalakshmi Pai G. A. A Textbook of Data Structures and Algorithms. – Wiley-ISTE, 2023. – 942 p.
6. Sachi Nandan Mohanty, Pabitra Kumar Tripathy. Data Structure and Algorithms Using C++: A Practical Implementation. – Wiley-Scrivener, 2021. – 419 p.

### Discipline "Programming"

7. Sachdeva D., Ustukpayev N. Mastering C++ Programming Language. – CRC Press, 2022. – 451 p.
8. Kirk D. R. Deciphering Object-Oriented Programming with C++. – Packt Publishing Pvt Ltd, 2022. – 594 p.
9. Forouzan B. A., Gilberg R. C++ Programming: An Object-Oriented Approach. – McGraw-Hill Education, Year: 2019. – 959 p.

### Discipline "Mathematical Methods of Operations Research"

10. Nickel S., Rebennack S., Stein O., Waldmann K.-H. Operations Research. – Springer Berlin Heidelberg, 2022. – 456 p.
11. Luenberger D. G., Ye Y. Linear and Nonlinear Programming. – Springer, 2021. – 624 p.
12. Hillier F., Lieberman G. Introduction to Operations Research. – McGraw Hill, 2020. – 992 p.

### Discipline: "Databases and Information Systems"

13. Foster E., Godbole S. Database Systems: A Pragmatic Approach. – CRC Press, 2022. – 596 p.
14. Friedrichsen L., Ruffolo L., Monk E. F., Starks J. L., Pratt P. J., Last M. Z. Concepts of database management. – Cengage Learning, 2021. – 418 p.
15. Rockoff L. The Language of SQL. – Addison-Wesley Professional, 2021. – 272 p.

### Discipline: "Web Programming and Web Design"

16. Dean J. Web Programming with HTML5, CSS, and JavaScript. – Jones & Bartlett Publishers, 2019. – 699 p.
17. Rebah H. B., Boukthir H., Chedebois A. Website Design and Development with HTML5 and CSS3. – Wiley-Iste, 2022. – 352 p.
18. Ackermann P. JavaScript: The Comprehensive Guide to Learning Professional JavaScript Programming. – Rheinwerk Computing, 2022. – 1344 p.

Approved at the session of the admissions committee..

Protocol № 16 dated 17.04.2023

Executive Secretary of the Admissions  
Committee

Head of the Professional Attestation  
Committee

  
(signature)

Roy I.O.  
(last name, initials)

  
(signature)

Drozdenko O.O.  
(last name, initials)

## Appendix A

SUMY STATE UNIVERSITY

Code \_\_\_\_\_

**ANSWER SHEET**  
**of the professional entrance examination for admission to study**  
**for the Master's degree in the specialty**  
**122 - "Computer Science"**

Variant № \_\_\_\_\_

(write a number of variant)

№	A	B	C	D	№	A	B	C	D	№	A	B	C	D
1.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	11.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	21.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	12.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	22.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	13.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	23.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	14.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	24.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	15.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	25.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	16.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	26.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	17.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	27.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	18.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	28.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	19.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	29.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	20.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	30.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**WARNING!!!** Tasks have only one correct answer.  
 Select the right answer and mark it as shown in the sample.  
 Number of corrections affect the overall evaluation of the work!

A	B	C	D
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Number of correct answers – \_\_\_\_\_ ;

The number of points – \_\_\_\_\_ ;

Number of corrections – \_\_\_\_\_ ;

The number of points removed for corrections – \_\_\_\_\_ ;

**Total number of points****without removed points –** \_\_\_\_\_

(in number and in writing)

Head of Committee

\_\_\_\_\_  
(signature)\_\_\_\_\_  
(last name, initials)

Members of the Committee

\_\_\_\_\_  
(signature)\_\_\_\_\_  
(last name, initials)\_\_\_\_\_  
(signature)\_\_\_\_\_  
(last name, initials)

**Appendix B**  
**SUMY STATE UNIVERSITY**

APPROVED BY  
Head of the Admissions Committee

\_\_\_\_\_ 20\_\_\_\_

**EXAMINATION TASK**  
**for the professional entrance examination for admission to study**  
**for the Master's degree in the specialty**  
**122 - "Computer Science"**

Variant № <u>  I  </u>
1. Insert operations (Push) on stack of n elements takes time...
A) $O(1)$ ;
B) $O(n)$ ;
C) $O(n+1)$ ;
D) $O(n^2)$ .
2. Let <i>aStack</i> is a stack of <i>n</i> elements, and <i>bStack</i> is addition empty stack. What tasks can be done using only Push(insert element) and Pop(delete element) operations?
I. Display elements of stack <i>aStack</i> in reverse order (Top element is displayed last)
II. Determine the number of <i>aStack</i> stack elements, leaving it unchanged.
III. Delete all occurrences of a particular item in the stack <i>aStack</i> , leaving the order of its other elements unchanged.
A) I and II only;
B) I and III only;
C) II and III only;
D) I, II and III.
3. Delete operations (Pop) on query of n elements takes time...
A) $O(1)$ ;
B) $O(n)$ ;
C) $O(n+1)$ ;
D) $O(n^2)$ .
4. Query is a data structure
A) with random access to items
B) with limited access to items
C) with occasional access to items
D) with shared access to items
5. The property "Generality" of the algorithm is defined as:
A) the algorithm can be used to solve a whole class of one-type tasks for which it was created;
B) the algorithm can be executed by anyone;
C) the algorithm is executed at least on one set of input elements;
D) the algorithm is not executed at least on one set of input elements.
6. Choose a term that does not belong to the DFD methodology:
A) external (to the information system) entity
B) process
C) data flow
D) attribute

7. Select a term that belongs to the ERD model:

- A) external (to the information system) entity
- B) entity
- C) data flow
- D) process

8. What result does return the SQL command: `SELECT 12*sal+comm FROM emp;`

If table EMP consists of only one row with feild sal equals 1000, and field comm equals NULL.

- A) 12000
- B) NULL
- C) error
- D) no row selected

9. This DDL command:

`ALTER TABLE InvItem ADD PRIMARY KEY (InvoiceNo, InvLineNo);`

- A) Adds new fields to the primary table key
- B) Adds primary compound table key
- C) Adds alternate table key
- D) Is not correct, because the primary key can be defined on table creation only.

10. Which of the following expressions is correct?

- A) `NULL = NULL`
- B) `NULL != NULL`
- C) `NULL <> NULL`
- D) All expressions are incorrect

11. What logic expression is equivalent to

$$\overline{A} \vee ABC \vee ABCD?$$

- A)  $\overline{A} \vee BCD$
- B)  $\overline{A} \vee BC;$
- C)  $\overline{A};$
- D) 0.

12. How many logical functions of two variables exist?

- A) 2;
- B) 4;
- C) 8;
- D) 16.

13. What formula can be simplified?

- A)  $\overline{y}z \vee \overline{y}z;$
- B)  $\overline{z} \vee \overline{x}y;$
- C)  $\overline{y}z \vee \overline{z}y;$
- D)  $\overline{z} \vee \overline{y}z.$

14. A necessary and sufficient condition for the existence of Euler circuit on connected graph is that

- A) all vertices have odd degree
- B) any two vertices have even degree and other vertices have odd degree
- C) all vertices have even degree
- D) any two vertices have odd degree and other vertices have even degree

15. What operations are Boolean?

- A)  $\rightarrow, \oplus, \neg$ ;
- B)  $\vee, \oplus$ ;
- C)  $\rightarrow, \uparrow$ ;
- D)  $\neg, \wedge, \vee$ .

16. What method uses formula  $x_n = x_{n-1} - \frac{f(x_{n-1})}{\frac{df(x_{n-1})}{dx}}$  for solving nonlinear equations?

- A) Iterative method;
- B) Bisection method;
- C) Newton's method;
- D) Secant method.

17. What method uses formula  $I = \frac{h}{2} \left( f(x_0) + f(x_n) + 2 \sum_{k=1}^{n-1} f(x_k) \right)$  for approximating the definite integral:

- A) Rectangle method;
- B) Trapezoidal method;
- C) Simpson's method;
- D) Gaussian method.

18. For an approximating the definite integral by the Simpson method, the curve of the integral function is replaced by:

- A) straight lines;
- B) sections of a quadratic parabola;
- C) linear spline;
- D) quadratic spline.

19. A necessary and sufficient condition for single unique solution of system of linear equations (SLEs) to exist is that

- A) the constant terms of SLEs are equal 0;
- B) the diagonal coefficients of SLEs are not equal 0;
- C) the determinant of the coefficient matrix of SLEs is not equal zero
- D) the coefficients of SLEs are equal or greater then 0;

20. What method is used for solving the system of nonlinear equations?

- A) The Method of Lagrange Multipliers;
- B) Bisection method;
- C) Runge-Kutta method;
- D) Newton's method.

21. What is the standart way for implementation of polymorphism in C++?

- A) multiple inheritance.
- B) virtual methods.
- C) virtual inheritance.
- D) abstract classes.

22. The program describes the class and object

```
class A {public: int a, b, c; }; A *obj;
```

How to refer to attribute c?

- A) `obj.c`
- B) `obj->c`
- C) `obj A -> -> c`
- D) `obj->A.c`



23. What function can NOT be a constructor?

- A) `void String ()`
- B) `String ();`
- C) `String (String & s)`
- D) `String (const int a)`

24. Select the correct statement about abstract class in the C++ language.

- A) A class is called abstract, if all methods of this class are purely virtual.
- B) The abstract base class imposes a certain interface to all classes derived from it.
- C) We cannot create objects of abstract classes, because it *contains at least one pure virtual function*
- D) Abstract class does not have any methods.

25. If the C++ program redefines the operation `new` for some arbitrary class, then ...

- A) all objects of this class and all objects of classes derived from it must use this operation regardless of scope where it was redefined.
- B) derivatives of this class can use a global operation by applying `base_class :: new`.
- C) operation `new` can't be redefined.
- D) in any case, this operation will be available within the descendant class only.

26. What does the abbreviation HTML stand for?

- A) HyperText Markup Language
- B) HighText Markup Language
- C) HyperText Markdown Language
- D) None of the above

27. How many sizes of headers are available in HTML by default?

- A) 1
- B) 3
- C) 5
- D) 6

28. How can you created rounded corners using CSS3?

- A) `border[round]: 30px;`
- B) `corner-effect: round;`
- C) `border-radius: 30px;`
- D) `alpha-effect: round-corner;`

29. How to add text shadow using CSS3?

- A) `font: shadowed 5px 5px 5px grey;`
- B) `font-shadow: 5px 5px 5px grey;`
- C) `shadow: text 5px 5px 5px grey;`
- D) `text-shadow: 5px 5px 5px grey;`

30. Which is the correct way to write a JavaScript array?

- A) `var txt = new Array(1:"arr",2:"kim",3:"jim")`
- B) `var txt = new Array("arr ","kim","jim")`
- C) `var txt = new Array:1=(" arr ")2=("kim")3=("jim")`
- D) `var txt = new Array=" arr ","kim","jim"`

Head of the Professional Attestation Committee

\_\_\_\_\_ Drozdenko O.O.