МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ

ЗАТВЕРДЖЕНО
на засіданні кафедри
інформаційних систем
Протокол № 1 від 22.08.2023 р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи

_____ Каріна НЕМАШКАЛО

ОСНОВИ АЛГОРИТМІЗАЦІЇ

робоча програма навчальної дисципліни (РПНД)

Галузь знань	**12 "Інформаційні технології"**
Спеціальність	**121 "Інженерія програмного забезпечення"**
Освітній рівень	**перший (бакалаврський)**
Освітні програми	**"Інженерія програмного забезпечення"**

Статус дисципліни	**обов'язкова**
Мова викладання, навчання та оцінювання	**англійська**

Розробник:
к.т.н., доцент _____ Олег ФРОЛОВ

Завідувач кафедри
інформаційних систем _____ Дмитро БОНДАРЕНКО

Гарант програми _____ Олег ФРОЛОВ

Харків
2024

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

APPROVED
at the meeting of the department
information systems.
Protocol № 1 of 22.08.2023

AGREED
Vice-rector for educational and methodological work

_____ Karina NEMASHKALO

BASICS OF ALGORITHM

Program of the course

Field of knowledge	**12 "Information technologies"**
Specialty	**121 "Software engineering"**
Study cycle	**first (undergraduate)**
Study programme	**"Software Engineering"**

Course status	**mandatory**
Language of teaching, learning and assessment	**English**

Developer:
Ph.D. (Technical sciences),
associate professor _____ Oleg FROLOV

Head of Information systems
department:
Ph.D. (Technical sciences),
associate professor _____ Dmytro BONDARENKO

Head of Study Programme:
Ph.D. (Technical sciences),
associate professor _____ Oleg FROLOV

Kharkiv
2024

INTRODUCTION

Wide circle of information technologies, scientific and technical progress, penetration of information and communication technologies into all spheres of human activity put forward new, increased requirements for the studying of specialists in the field of information technologies. A modern professional in this field must possess a number of competencies, among which a special place is occupied by general scientific and general technical competencies, or, in other words, fundamental knowledge.

In the general case, the course "Basics of algorithm" considers such issues as the formalization of the concepts of "algorithm", "algorithm complexity" and the study of formal algorithmic systems; general principles of building effective algorithms; modern methods of algorithm research and analysis; methods and mechanisms of implementation of effective algorithms in specific applications; classification of tasks, definition and study of classes of complexity; asymptotic analysis of algorithm complexity; research and analysis of recursive algorithms; obtaining explicit functions of labor intensity for comparative analysis of algorithms; development of criteria for comparative evaluation of the quality of algorithms.

The course "Basics of algorithm" is studied by students of the "Software engineering" specialty of all forms of study in the first year during the first semester.

The goal of teaching the course is to form students a system of theoretical knowledge, applied skills, and practical skills in developing basic algorithms used to solve applied problems from various subject areas.

The tasks of the course are:

- formation of a system of knowledge on the theory of algorithms, principles of organization of algorithmic processes and forms of their implementation;
- acquainting applicants with modern and effective computer information processing algorithms, as well as methods of their research and analysis.

Object of the course are algorithms for solving typical mathematical and applied problems.

Subject of the course are the main approaches and methods for the development and implementation of algorithms for solving applied problems based on the application of basic algorithmic structures and basic data structures.

In the process of training, students acquire the necessary knowledge during lectures and performing laboratory work. Self-studies is also of great importance in the process of studying and consolidating knowledge. All types of classes are developed in accordance with the transfer system of the organization of the educational process.

The learning outcomes and competence formed by the course are defined in the table. 1.

Table 1

Learning outcomes and competencies formed by the course

Learning outcomes	Competences
LO 12	SC 01, SC 02, SC 14
LO 13	GC 01, GC 02, SC 02, SC 14

where, GC 01. Ability to think abstractly, analyze and synthesize;

GC 02. Ability to apply knowledge in practical situations;

SC 01. Ability to identify, categorize and formulate software requirements;

SC 02. Ability to participate in the design of software, including modelling (formal description) of its structure, behaviour and processes of operation;

SC 14. Ability to think algorithmically and logically;

LO 12. Apply effective software design approaches in practice;

LO 13. Know and apply methods of developing algorithms, designing software and data and knowledge structures.

COURSE CONTENT

Content module 1. Concept of algorithm and its formalization.

Topic 1. The concept of an algorithm. Basic properties of algorithms.

1.1. Introduction. The purpose and tasks of the course, its place in the educational process. The structure of the course, recommendations for its study. Organizational and methodological support of the course.

1.2. Algorithm. Intuitive concept of algorithm. Recording methods and properties of algorithms. Constructive objects as data. The need to clarify the concept of algorithm. Requirements for the general algorithmic model.

1.3. Types of computational processes. Variety of algorithms. Types of computational processes: linear, branched, cyclic. An example of the development of a simple algorithm. Variety of problem solving with algorithms

Topic 2. Algorithm development methods.

Algorithm development methods: structural programming, recursion, tree traversal, divide and rule, balancing, dynamic programming, backtracking, branch-and-bound method, heuristic and approximate algorithms.

Topic 3. Concept of computational complexity of algorithms.

Basics of algorithm analysis. Asymptotic analysis of upper and middle estimates of algorithm complexity; comparison of the best, average and worst grades; O-, o-, θ-notations; empirical measurements of algorithm efficiency; overhead costs of algorithms in terms of time and memory; recursive relations and analysis of recursive algorithms.

Topic 4. Processing of one-dimensional arrays.

4.1. The concept of an array. One-dimensional array. Basic typical algorithms for working with one-dimensional arrays.

4.2. Searching for an element in an array. Array sorting. Examples of algorithms using one-dimensional arrays.

4.3. Complexity and optimization of one-dimensional array processing algorithms.

Topic 5. Concept of recursion. Recursive algorithms.

The concept of recursion. Recursion and cyclic algorithms. Exceptions related to recursive data processing. Mutual recursion.

Content module 2. Universal computational models.

Topic 6. Posta's car.

The concept of a universal computing model. The use of universal computing models for the formalization of the concept of "algorithm". The Post machine as a universal computing model. Post machine command system.

Topic 7. Turing machines and machines with unlimited registers.

The concept of the universal model "Turing machine". Composition and principle of operation of the Turing machine. Turing machine command system. Turing machine capabilities. The main hypothesis of the theory of algorithms.

Topic 8. Normal Markov algorithms.

Markov substitutions. Normal algorithms and their application to words. Normally calculated functions and the principle of Markov normalization. Coincidence of the class of all normally computable functions with the class of Turing computable functions. Equivalence of different theories of algorithms.

Content module 3. Fundamental algorithms of data processing.

Topic 9. Positional and non-positional counting systems.

9.1. Numerical systems. Presentation of numbers in positional systems. Binary and non-binary Gray codes.

9.2. Presentation of numerical data in the computer: integers and real numbers. Algorithms for performing arithmetic operations.

Topic 10. Basic data structures.

10.1. Introduction to data structures. The abstract data type is "List". Implementation of lists using arrays. Implementation of lists using instructions. Comparison of implementations. Implementation of lists based on cursors. Doubly linked lists.

10.2. Stack and Queue abstract data types. Implementation of stacks using arrays. Implementation of stacks using pointers. Implementation of queues using pointers. Implementation of queues using cyclic arrays.

Topic 11. Algorithms for working with integers.

Euclid's algorithm. The greatest common denominator. Least common multiple. Sieve of Eratosthenes. Sundaram Sieve. Atkin sieve. Check for simplicity. Basic theorem of arithmetic. Decomposing a number into prime factors. Euler's function. Number of divisors.

Topic 12. Algorithms of sorting, merging and searching.

12.1. The importance of sorting when implementing algorithms. Sorting classification. Sorting characteristics. Simple sorting as a way to quickly implement the algorithm. Examples of simple sorts are simple inclusion method, simple exchange method (bubble sort), shaker sort, insertion sort, counting sort, numerical

sort. Advantages and disadvantages of simple sorting.

12.2. Complex sorting as a way to create efficient algorithms. Examples of complex sorts are Shell sort, Hoare sort (quick sort), merge sort. Advantages and disadvantages of complex sorting. Comparison of simple and complex sorting.

12.3. Search algorithms. Linear search. Binary search. Interpolation method. Sequence search algorithms.

The list of laboratory studies in the course is given in table 2.

Table 2

The list of laboratory studies

Title of the topic and task	Content
Topic 1. Task 1.	Development of schemes of algorithms of linear computational processes
Topic 2. Task 2.	Development of schemes of algorithms of branched computational processes
Topic 3, Topic 4, Topic 5. Task 3.	Development of schemes of algorithms of cyclic computing processes
Topic 6. Task 4.	Development of programs for the Post machine
Topic 7. Task 5.	Development of programs for the Turing machine
Topic 8, Topic 9. Task 6.	Development of Normal Markov algorithms
Topic 10, Topic 11, Topic 12. Task 7.	Simple sorting and searching algorithms

The list of self-studies in the course is given in table 3.

Table 3

List of self-studies

Name of the topic and / or task	Content
Topic 1 - 12	Studying lecture material
Topic 1 - 12	Preparation for laboratory classes
Topic 1 - 12	Preparation for the exam

The number of hours of lectures, laboratory classes and hours of self-study is given in the technological card of the course.

TEACHING METHODS

In the process of teaching the course, in order to acquire certain learning outcomes, to activate the educational process, it is envisaged to use such teaching methods as:

Problem lecture (Topic 1), verbal (lecture (Topic 2, 4, 5, 6, 7, 8, 9, 10, 11, 12)), dialogue lecture (Topic 3).

In person (demonstration (Topic 1 - 12)).

Practical (laboratory work (Topic 1 - 12), case studies (Topic 4)).

FORMS AND METHODS OF ASSESSMENT

The University uses a 100-point cumulative system for assessing the learning outcomes of students.

Current control is carried out during lectures, laboratory classes and is aimed at checking the level of readiness of the student to perform a specific job and is evaluated by the amount of points scored:

– for courses with a form of semester control as an exam: maximum amount is 60 points; minimum amount required is 35 points.

The final control includes current control and an exam.

Semester control is carried out in the form of a semester exam.

The maximum number of points that a student of higher education can receive during the examination (examination) is 40 points. The minimum amount for which the exam is considered passed is 25 points.

The final grade in the course is determined:

– for courses with a form of exam, the final grade is the amount of all points received during the current control and the exam grade.

During the teaching of the course, the following control measures are used:

Current control: presentation of laboratory tasks (48 points), current control works (12 points).

Semester control: Grading including Exam (40 points)

More detailed information on the assessment system is provided in technological card of the course.

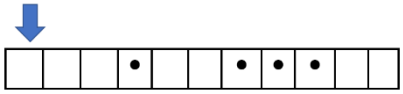
An example of an exam card

Semyon Kuznets Kharkiv National University of Economics
First (bachelor) level of higher education
Specialty "Software Engineering"
Study programme "Software engineering"
Course "Basics of algorithm"

EXAM CARD No. 1

Task 1. Develop an algorithm scheme for determining the sum of even elements of a one-dimensional array between the first and last even elements of the array inclusively.

Task 2. Determine the result of the program for the Post machine.



1. →
2. ? 1, 3
3. →
4. 1
5. .

Task 3. Explain the principle of operation of the simple exchange sorting algorithm. Arrange the given numerical sequence in ascending order using the specified algorithm, while recording all intermediate states of the sequence that are determined after each pass through the array.

6 3 2 1 9 4 5 8 7 0

Task 4. Describe the Turing machine that implements the given algorithm with a function table. Initial and final configurations are standard. Increase by 7 a positive number in the number system (0,1). Write down the sequence of Turing machine configurations for the word 1000.

Task 5. Develop a normal Markov algorithm, which for any word in the alphabet A={0,1}, considering this word as a binary number, determines whether it is odd. Answer: word 1 if yes, or word 0 otherwise.

Protocol No. ____ dated "___"_____20___ was approved at the meeting of the Department of Computer Systems and Technologies.

Examiner Ph.D., Assoc. Frolov O. V.

Chief Department of Ph.D., Assoc. O. D. Bondarenko

Evaluation criteria

The final marks for the exam consist of the sum of the marks for the completion of all tasks, rounded to a whole number according to the rules of mathematics.

Each task of the exam ticket is evaluated for a maximum of 8 points. The number of points obtained from the answers to each question of the examination ticket is summed up. As a result of such a calculation, the applicant can receive from 0 to 40 points.

The assessment of the exam result is formed according to the following rules:

1. Task 1 can be assigned from 0 to 8 points (for the presence of an array input algorithm - 1 point, correct determination of the limit values of the processing range - 3 points, implementation of the processing algorithm - 2 points, taking into account possible cases of non-existence of a solution - 2 points); task 2 can be awarded from 0 to 8 points; task 3 can be assigned from 0 to 8 points (Comprehensive explanation of the principle of operation of the algorithm 3 points, the correctness of the definition of intermediate states - 5 points); task 4 can be awarded from 0 to 8 points (making a function table - 6 points, determining the sequence of Turing machine configurations 2 points), task 5 can be awarded from 0 to 8 points (the correct sequence of substitutions - 6 points, the presence of examples and explanations - 2 points).
2. 1 point is added for several solutions to one of the tasks.
3. 1 point is added for choosing the option that is optimal from several solution options and justifying the choice.

RECOMMENDED LITERATURE

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