**Syllabus**

**"Algorithm Design and Analysis"**

Approved by

The Academic Council

Protocol No 19/2  June 25, 2019.

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|---|---|
| Author | Karpova Irina |
| Credits | 2 |
| Contact work (hours) | 10 |
| Individual work (hours) | 66 |
| Course | 2 |
| The format of the discipline | Blended learning |

## I. Purpose, Learning Outcomes and Prerequisites

**Purpose**

The purpose of this course is learn to design efficient and correct algorithms using sophisticated data structures for complex computational tasks.

**About this course**

How do you optimally encode a text file? How do you find shortest paths in a map? How do you design a communication network? How do you route data in a network? What are the limits of efficient computation?

This course, part of the Computer Science Essentials for Software Development Professional Certificate program, is an introduction to design and analysis of algorithms, and answers along the way these and many other interesting computational questions.

You will learn about algorithms that operate on common data structures, for instance sorting and searching; advanced design and analysis techniques such as dynamic programming and greedy algorithms; advanced graph algorithms such as minimum spanning trees and shortest paths; NP-completeness theory; and approximation algorithms.

After completing this course you will be able to design efficient and correct algorithms using sophisticated data structures for complex computational tasks.

**Learning Outcomes**

After completing “Algorithm Design and Analysis” course, a successful student will know:

- How to represent data in ways that allow you to access it efficiently in the ways you need to.
- How to analyze the efficiency of algorithms.
- How to bootstrap solutions on small inputs into algorithmic solutions on bigger inputs.
- Solutions to several classic optimization problems.
- How to critically analyze whether a locally optimal approach (greedy) can provide a globally optimal solution to a problem.

**Prerequisites**

- Discrete Mathematics - sets, functions, relations; proofs, and proofs by induction; Boolean logic.
- Basic probability.
- Basic knowledge of Java.

**Post requisites**

Knowledge and skills that a student will gain after successful accomplishment of the course he can apply to write a master's thesis.

## II. Topic-wise Course Content

**Topic 1.** Mathematical Preliminaries; Asymptotic analysis and recurrence relations; Sorting and Searching; Heaps and Binary Search Trees.

**Topic 2.** Algorithm Design Paradigms - Divide-and-Conquer algorithms, Dynamic Programming, Greedy Algorithms.

**Topic 3.** Graphs and graph traversals; minimum spanning trees; shortest paths.

**Topic 4.** Flows; NP-completeness; Approximation Algorithms.

## III. Assessment

Current control of knowledge is not provided.

Exam at the end of the course implies arrangement of the oral examination for all students enrolled to the course. Topics covered by the test embraces all course material. If a student misses the exam because of some valid reason, s/he receives «absence» grade. The exam is assessed on usual 10-point scale.

## IV. Evaluation tools for student certification assessment

Oral exam at the end of the course includes a theoretical question and a practical task.

The topics covered cover all course materials.

**Topics for course final assessment**

1. Mathematical Preliminaries.

2. Asymptotic analysis and recurrence relations.
3. Sorting and Searching.
4. Heaps and Binary Search Trees.
5. Algorithm Design Paradigms - Divide-and-Conquer algorithms.
6. Dynamic Programming.
7. Greedy Algorithms.
8. Graphs and graph traversals; minimum spanning trees.
9. Graphs and graph traversals; shortest paths.
10. Flows. NP-completeness.
11. Approximation Algorithms.

## V. Reading list

### 5.1 Required

1. Jeffrey J. McConnell. Analysis of Algorithms: An Active Learning Approach. Jones and Bartlett Publishers, Boston. 2001. – 297 p. URL: http://lib.mdp.ac.id/ebook/Karya%20Umum/Analysis-of-Algorithms.pdf.

2. Herbert Edelsbrunner. Design and Analysis of Algorithms. 2008. – 95 p. URL: https://www2.cs.duke.edu/courses/fall08/cps230/Book.pdf.

### 5.2 Optional

1. Steven S. Skiena. The Algorithm Design Manual. Second Edition. State University of New York at Stony Brook, New York, USA, Springer, 2008. ISBN: 978-1-84800-069-8. 730 p. URL: http://mimoza.marmara.edu.tr/~msakalli/cse706_12/SkienaTheAlgorithmDesignManual.pdf.

2. Baase, S. and Van Gelder, A. Computer Algorithms. Addison Wesley Longman, Reading, MA, 2000.

3. Knuth, D. E. The Art of Computer Programming: Volume 3 Sorting and Searching, 2d ed. Addison-Wesley, Reading, MA, 1998.

## VI. Resources

### 6.1. Software

| № | Title | Access conditions |
|---|---|---|
| 1. | JetBrains IntelliJ IDEA Community Edition | Free software license |
| 2. | NetBeans Community NetBeans | Free software license |

### 6.2. Material and technical support of the discipline

Computer class having Microsoft Windows 7 (or later), JetBrains IntelliJ IDEA Community Edition or NetBeans Community NetBeans installed.