

Reference Materials for HSE Global Scholarship Competition — 2022

Information Technology

I. Contents. Topic Overview

Topic 1. Integer arithmetic. Arithmetic operations (multiplication, division, remainder, addition, subtraction). Bit operations and operations with individual bits.

Topic 2. Conditional operator. Branching, if-else and if else-if conditions, choosing from multiple options.

Topic 3. Real arithmetic. Arithmetic operations with real numbers. Accuracy. Rounding.

Topic 4. Cycle operators. For, while, do ... while cycle operators. Break and continue operators.

Topic 5. Arrays. One-dimensional and multidimensional arrays. Dynamic memory allocation. Array input and output.

Topic 6. Procedures and functions. Local and global variables. Passing arguments by value and by reference. Recursion.

Topic 7. String operations. Standard string processing functions. Finite machines.

Topic 8. Arithmetic algorithms. GCD and LCM, number systems, long arithmetic, prime numbers and prime factor decomposition, remainders, fast exponentiation.

Topic 9. Search algorithms. Linear search, binary search, searching substring in a string, two pointers technique.

Topic 10. Sorting algorithms. Counting sort, selection sort, bubble sort, using default sorting.

Topic 11. Brute-force search and optimization methods. Exhaustive search, relation to the numerical system tasks. Recursive brute-force search and optimization methods.

Topic 12. Dynamic programming. Recurring sequences, simple dynamic programming. Dynamic programming with multiple parameters, by substrings, by subsets, by profile, by subtrees.

Topic 13. Greedy algorithm. Applications and conventional problems solved by the greedy algorithm. Proof of applicability.

Topic 14. Algorithms based on unweighted graphs. Breadth first and depth first graph traversals. Their application. Topological sorting, component coupling, cycle detection, bipartite check, bridges, articulation points, condensation. Matching. Eulerian path.

Topic 15. Algorithms based on weighted graphs. Shortest path algorithms — Dijkstra, Bellman-Ford, Floyd-Warshall. Minimum spanning trees. Streams.

Topic 16. Computational geometry. Scalar and skew product. Areas. Relative position of shapes on a plane and in space. Convex shells.

Topic 17. Linear data structures. Stack, queue, double-ended queue. Solving the problem of checking the correct bracket sequence, window minimum, reverse Polish notation.

Topic 18. Trees. Binary search tree. Self-balancing binary search tree. Rooted trees, non-overlapping sets. Segment tree, solving RMQ and RSQ tasks. Heap. Fenwick tree. Cartesian trees.

Topic 19. Hashes and hash tables. Hash functions, remainders. Hash tables. Solving the mass substring search problem using a suffix array. Binary search with prefix hashes.

Topic 20. Sparse tables. Sparse tables. Application of sparse tables to solve the problem of finding the lowest common ancestor in a tree.

Topic 21. Heuristic methods and conventional concepts. Divide-and-conquer method, Monte Carlo method, meet-in-the-middle.

II. Recommended sources

- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to Algorithms.

URL:

[http://sd.blackball.lv/library/Introduction to Algorithms Third Edition \(2009\).pdf](http://sd.blackball.lv/library/Introduction%20to%20Algorithms%20Third%20Edition%20(2009).pdf)

III. Online sources

- Python for Everybody Specialization. URL:
<https://www.coursera.org/specializations/python>

- Data Structures and Algorithms Specialization. URL:
<https://www.coursera.org/specializations/data-structures-algorithms>