Introduction to advanced data structures and algorithms

# Introduction to advanced data structures and algorithms

**CSEN 1038** 

German University in Cairo

#### Outline

- 1 Motivation
- 2 Problem Solving Methodology
- 3 Administrivia
- 4 Lab Zero

# Why study advanced data structures and algorithms?

- Tasks
  - set-set intersection
  - sorting and retrieval

#### Problems

deleting database records with dependency constraints Conflict resolution among versions (e.g. version control distributed database eventual consistency)

# Why study advanced data structures and algorithms?

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- Conflict resolution among versions (e.g. version control, distributed database eventual consistency)

## Why study advanced data structures and algorithms?

A competitive programming based course





#### Problem Solving Methodology



Adopted from The Art and Craft of Problem Solving

#### └─ Strategies

- Read the problem carefully
- Visualize
- Draw observations, Make Conclusions
- Get your hands dirty
- Build and trust your intuition
- Argue for your solution
- Stuck? Explore other ways

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#### Methods applicable to different settings

- Cyclic dependencies or recursive relationships
  - Graph modeling
- Range queries
  - Precomputation or dedicated data structures
- Optimization problems
  - Invariants or monotonicity

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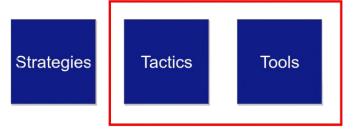
Introduction to advanced data structures and algorithms

— Problem Solving Methodology

#### Tools

Focused techniques and tricks for specific situations.

Problem Solving Methodology



- What it is
  - practical
  - implementation oriented
- What it is not
  - theoretically formal
    - heavily rigorous

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#### Course Material

All course material will be uploaded here https://github.com/AhmadHoseiny/ADSA-2025

#### Course Resources

- https://cp-algorithms.com/
- Introduction to Algorithms, 3rd Edition (CLRS) by Cormen, Leiserson, Rivest, and Stein.

#### Course Assessment

- All assessments will be in the form of Codeforces contests and problems
- Lab and Home assignments are weekly based
- Attendance of lectures is highly recommended

Lab Assignments	20%
Home Assignments	50%
Project	30%

#### Course outline

Week	Торіс
1	Introduction
2	Persistent Data Structures and Disjoint Sets Union
3	Matrix Exponentiation
4	Segment Trees with Lazy Propagation
5	Binary Search, Backpropagation and Meet in the Middle
6	String Processing Algorithms
7	Fast Fourier Transform
8	Strongly Connected Components and 2SAT Problem
9	Lowest Common Ancestor
10	Advanced Dynamic Programming
11	Max Flow Algorithms
12	Joker

#### Lab Zero

# Lab Zero

#### Lab Zero Codeforces

#### Codeforces



time limit per test: 1 second memory limit per test: 256 megabytes

Cube is given an integer n. She wants to know how many ordered pairs of positive integers (a,b) there are such that a=n-b. Since Cube is not very good at math, please help her!

#### Input

The first line contains an integer t (1  $\leq t \leq$  99) — the number of test cases.

The only line of each test case contains an integer n ( $2 \le n \le 100$ ).

#### Output

For each test case, output the number of ordered pairs (a,b) on a new line.

#### Example



```
Lab Zero
```

└ Java Refresher

#### Java Refresher - Sorting

```
Car[] arr = new Car[5];
Comparator<Car> c = (Car a, Car b) -> {
    return a.price - b.price;
};
Arrays.sort(arr, c);
// Collections.sort for ArrayList, LinkedList, etc.
```

#### Remark

Time complexity of the sorting is  $O(n \log n)$ 

```
Lab Zero
```

L Java Refresher

#### Java Refresher - HashSets

```
HashSet<Integer> hs = new HashSet<>();
hs.add(e:1);
hs.add(e:2);
if(hs.contains(o:1)){
    // do something
}
hs.remove(o:1);
```

#### Remark

Time complexity of these methods is roughly O(1)

```
Lab Zero
```

└ Java Refresher

# Java Refresher - HashMaps

```
HashMap<Integer, Integer> hm = new HashMap<>();
hm.put(key:1, value:2);
hm.put(key:2, value:3);
if(hm.containsKey(key:1)){
    System.out.println(hm.get(key:1));
}
hm.remove(key:1);
```

#### Remark

Time complexity of these methods is roughly O(1)

Graphs Refresher

# Graphs Refresher - Representation

- Adjacency Matrix
- Adjacency List

Lab Zero
Graphs Refresher

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- Adjacency Matrix
- Adjacency List

```
Lab Zero
```

Graphs Refresher

#### Graphs Refresher - DFS

```
static ArrayList<Integer>[] adjL;
static boolean [] visited;
public static void dfs(int node){
    visited[node] = true;
    for(int child : adjL[node]){
        if(!visited[child]){
            dfs(child);
```

#### Remark

Time complexity of DFS O(n+m)

-Lab Zero

#### Codeforces

Let's ace some problems!