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# Algorithms and Data Structures – Conditional Course

## Winter Term 2026/27

### Exercise Sheet 2

**Due:** Wednesday, 04 November 2026, 12:00

#### Exercise 1: Hacked?

*(10 Points)*

A system administrator analyzes login times to detect suspicious behavior. If a user logs in twice in succession “inhumanly quickly”, the user was probably a bot. You are given a list of  $n$  integers representing login times. Determine the smallest absolute difference between two times.

**Example** Consider the array

$$A = [-20, 10, -18, 15, -100, 30, 98].$$

We seek the smallest absolute difference between two distinct entries, namely

$$\min_{1 \leq i < j \leq n} |A[i] - A[j]|.$$

For this array, the minimum is  $|-20 - (-18)| = 2$ .

- (a) Implement a brute-force algorithm that checks every pair to find the minimum absolute difference. What is its asymptotic running time? *(2 Points)*
- (b) Design a more efficient algorithm. First describe it in words, then implement it. Explain why it is correct and give its asymptotic running time.<sup>1</sup> *(6 Points)*
- (c) The website provides `input.txt`, containing 1000000 distinct integers. Use your implementation to compute the answer for this input and report the result. *(2 Points)*

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<sup>1</sup>The template includes a helper function `compare_runtimes`. Use it to see how your improved algorithm performs.

## Exercise 2: O-Notation

(10 Points)

- (a) Prove or disprove the following statements using the definition of Landau notation from the lecture.<sup>2</sup>

$$\sum_{i=0}^n i \in \Omega(n^2)$$

(2 Points)

$$n^{1/2} \cdot n^{1/3} \cdot n^{1/4} \in \Theta(n)$$

(2 Points)

$$3n \log n + 7n \in \Theta(n \log n)$$

(2 Points)

- (b) Give two functions  $f, g$  such that

$$f(n) \in O(g(n)) \quad \text{but} \quad f(n) \notin \Theta(g(n)).$$

Prove that your functions have these properties. You may use limits for this part. (4 Points)

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<sup>2</sup>A proof using only limits receives no points.