

# PRACTICE EXAM

**Difficulty: MEDIUM**

**Questions: 10**

## Algorithms and Data Structures Exam

Instructions: Please answer all questions to the best of your ability. Show your work for problem-solving questions to receive partial credit.

### # Section 1: Multiple Choice (4 points each, 40 points total)

Instructions: Choose the best answer for each of the following questions.

**Question 1:** What is the main purpose of the `key` variable in the provided INSERTION-SORT algorithm?

- A) To store the index of the element being inserted.
- B) To temporarily hold the value of the element being inserted.
- C) To track the number of comparisons made.
- D) To indicate whether the array is sorted.

**Question 2:** In the INSERTION-SORT algorithm, the `while` loop condition `i > 0 and A[i] > key` serves which primary purpose?

- A) To iterate through the entire array.
- B) To find the correct position to insert the `key` by comparing it with previous elements.
- C) To ensure the `key` is not smaller than the first element.
- D) To swap elements in the array.

**Question 3:** According to the merging of two sorted arrays algorithm discussed, what is the correct next step?

- A) Divide the array.
- B) Compare only the max values in each array.
- C) The merging of each element.
- D) Divide the list in half.

**Question 4:** In the recurrence relation analysis, which of the following represents the correct formula?

- A)  $T(n) = 2T(n/2) - \Theta(n)$
- B)  $T(n) = 2T(n/2) + \Theta(n)$
- C)  $T(n) = T(n/2) + \Theta(n)$
- D)  $T(n) = 2T(n) + \Theta(n/2)$

## # Section 2: Short Answer (6 points each, 30 points total)

Instructions: Answer each question in 2-3 sentences.

**Question 5:** Briefly explain the role of the index variable `i` in the inner `while` loop of the INSERTION-SORT algorithm.

**Question 6:** In the recurrence relation examples, what is the significance of finding both an upper bound and a lower bound?

**Question 7:** Explain in simple terms, the purpose of the recurrence tree in the context of algorithm analysis.

## # Section 3: Problem-Solving (10 points each, 30 points total)

Instructions: Provide detailed solutions and justifications for each problem.

**Question 8:** Trace the INSERTION-SORT algorithm on the array `[5, 1, 4, 2, 8]`. Show the state of the array after each iteration of the outer `for` loop.

**Question 9:** Given two sorted arrays, `A = [1, 3, 5]` and `B = [2, 4, 6]`, manually merge them into a single sorted array `C`. Show each step of the merging process.

**Question 10:** Consider the recurrence relation  $T(n) = T(n-1) + n$ . Using the guess  $T(n) \leq cn^2$ , show the upper bound analysis to determine the constant 'c'.