

PRACTICE EXAM

Difficulty: MEDIUM

Questions: 10

Data Structures and Algorithms Exam

Instructions: Please answer all questions to the best of your ability.

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

Instructions: Choose the *single best* answer for each question.

Question 1: What is the primary purpose of the "key" variable in the given Insertion Sort algorithm?

- A) To store the index of the element being inserted.
- B) To hold the value of the element being inserted into its correct position.
- C) To track the number of comparisons made during the sorting process.
- D) To indicate whether the array is already sorted.

Question 2: Based on the provided examples of merging sorted arrays, what can be said about how this operation handles duplicate values?

- A) Duplicate values are always removed.
- B) Duplicate values are kept in their original order and position.
- C) Duplicate values are merged together.
- D) The behavior with duplicate values is unpredictable.

Question 3: According to the provided recursion examples, what is the base case for the recurrence relation $T(n) = T(n-1) + \lg n$?

- A) $n = 0$
- B) $n = 1$
- C) $n = 2$
- D) $n = \lg n$

Question 4: Which of the following Big O notations represents the complexity of $\lg n!$?

- A) $O(n)$
- B) $O(\lg n)$
- C) $O(n \lg n)$
- D) $O(n^2)$

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

Instructions: Answer each question concisely in 2-3 sentences.

Question 5: Explain in your own words the role of the `while` loop within the provided Insertion Sort algorithm.

Question 6: What is the significance of finding a value for 'c' when using the substitution method to prove the upper or lower bound of a recurrence relation?

Question 7: Based on the provided data, how does insertion sort swap the elements?

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

Instructions: Show all your work and explain your reasoning.

Question 8: Using the substitution method, demonstrate that $T(n) = 2T(n/2) + n$ is $O(n \log n)$. Assume $T(1) = 1$. *You do not need to prove a base case*.

Question 9: Given the initial unsorted array `[9, 8, 2, 4, 9, 3, 6]`, demonstrate the steps of Insertion Sort to sort this array in ascending order. Show the array's state after each pass of the outer loop.

Question 10: What is one advantage and one disadvantage of recursion tree method over the substitution method?