CS340 – Advanced Data Structures and Algorithm Design – Fall 2020
Assignment 5 – October 21, 2020

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due October 30, 2020, 10.00 am

Problem 1 (4+3 marks).

(a) Illustrate how the list 5, 13, 2, 25, 7, 17, 20, 8, 4 is sorted with Mergesort. Count the number of comparisons made.

(b) Illustrate how the list 5, 13, 2, 25, 7, 17, 20, 8, 4 is sorted with Heapsort.

Problem 2 (2+3 marks). Assume your sorting algorithms have to deal with lists that can potentially contain duplicates. Assume the same sorting algorithms as discussed in class / in the textbook.

(a) What is the running time of Insertion Sort when all elements in a given list of length N are equal? Explain your answer.

(b) Give a Θ-bound on the running time of Mergesort for the case that all elements in a given list of length N are equal (assuming N is a power of 2). Explain your answer.

Problem 3 (4 marks). A sorting algorithm is *stable* if the relative order of any two equal entries in the given array stays the same: when two records `a[i]` and `a[j]` are equal in content, and `i < j`, then the algorithm sorts the array in a way that the record originally stored in `a[i]`, still appears to the left of the record originally stored in `a[j]`, when the array is sorted. Which of the algorithms Insertion Sort, Shellsort, Heapsort, and Mergesort (as presented in class) are stable, which are not?

Problem 4 (2+2+2+2 marks). Analyze the following recurrence relations using the Master Theorem, and give a Θ-bound for each.

(a) $T(N) = 2T(N/4) + 1$.

(b) $T(N) = 2T(N/4) + \sqrt{N}$.

(c) $T(N) = 2T(N/4) + N^2$.

(d) $T(N) = 9T(N/3) + N$.

Problem 5 (2 marks). Explain why the Master Theorem cannot be applied to the recurrence relation $T(N) = 2T(N/2) + N\log(N)$.