Helsinki University of Technology
Laboratory of Software Technology
T-106.1220/1223 Data Structures and Algorithms T/Y

EXAMINATION
22.12.2006

Write in each paper your name, student number *with checking letter*, study program, and the course code and name "T-106.1220 Data Structures and Algorithms T" or "T-106.1223 Data Structures and Algorithms Y". Write also date, hall, number of papers you return, and your *signature*.

1. Binary Heap and Algorithm Analysis (2p + 2p + 2p + 2p + 2p)

The following algorithm can restore the heap order property. Read all the items a)...e) before you start answering to the following questions about the algorithm.

```
MAX-HEAPIFY(A,i)
1     l = LEFT(i)
2     r = RIGHT(i)
3     if l ≤ heap-size[A] and A[l] > A[i]
4          then largest = l
5          else largest = i
6     if r ≤ heap-size[A] and A[r] > A[largest]
7          then largest = r
8     if largest ≠ i
9          then swap A[i] ↔ A[largest]
10               MAX-HEAPIFY(A, largest)
```

a) *Describe* the *basic principle* of the algorithm verbally.

b) <u>*Underline*</u> from your answer in item a) those *lines* that match the code lines 6-7.

c) *Give an example*, which illustrates also the recursive nature of the algorithm. *Draw figures* that show how the input array `A` is changed during the execution of the algorithm.

d) In lines 1 and 2, the algorithm computes the left and right children of node `i`, respectively, in complete binary tree. *Give pseudocode* implementations for the corresponding functions `LEFT(i)` and `RIGHT(i)`.

e) *Analyse the worst-case running time* of the algorithm in case the size of the array `A` is N = `heap-size[A]`. You can assume that the swap of array elements in line 9 can be executed in constant time. *Give* your final *answer in Big Oh notation.*

TURN

2. Hashing (2p + 6p)

a) *Describe the basic principles* of hashing.

b) *Assess the upsides and downsides* of hashing. For what kind of applications the hashing methods discussed in this course are suitable, and for what kind of applications they are unsuitable?

3. Sorting (10p)

Consider a task in which you have to chooce an algorithm for sorting given data. What kind of things you take into account and which algorithms you recommend for different cases? *Name and justify three criteria* in light of which you *examine three* different *sorting methods.*

4. Minimum Spanning Tree (4p + 2p + 4p)

a) *Describe an algorithm* that computes a minimum spanning tree for a graph.

b) *Analyse the running time* of the algorithm you described in item a) in case the graph has V vertices and E edges. *Justify your answer.*

c) *Illustrate* how to find the minimum spanning tree for a graph by applying the algorithm you described in item a). Let us consider the following weighted undirected graph that has the vertices A-F and edges AB(2), AD(3), AE(6), BC(4), BE(3), CE(1), CF(3), DE(1), EF(3). The weights of the edges are in parenthesis. The start vertex is A.

5. Estimate how much time did you spend for this final examination (this has no influence on grade).