

EE2008 / IM1001

NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2016-2017

EE2008 / IM1001 – DATA STRUCTURES AND ALGORITHMS

April / May 2017

Time Allowed: 2½ hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 4 pages.
2. Answer ALL questions.
3. All questions carry equal marks.
4. This is a closed-book examination.
5. Unless specifically stated, all symbols have their usual meanings.

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1. (a) Determine the asymptotic upper bound for the number of times the statement “ $r = r + 1$ ” is executed in the following algorithm.

```
for  $i = 1$  to  $n$ 
  for  $j = 1$  to  $i$ 
    for  $k = j$  to  $n$ 
       $r = r + 1$ 
```

(5 Marks)

- (b) Use mathematical induction to prove that the following equation is true for every positive integer $n \geq 1$.

$$\sum_{i=1}^n (a_i - a_{i-1}) = a_n - a_0$$

(6 Marks)

Note: Question No. 1 continues on page 2.

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- (c) Determine the asymptotic upper bound of the following functions using the $O(g(n))$ notation with the simplest function $g(n)$ possible.

- (i) $2n \lg(n-2)^2$
- (ii) $n!$

(8 Marks)

- (d) Consider a singly-linked list S with the pointer $start$ pointing to the first node of the list. Each node in the list S stores an integer value. Write an algorithm that computes the sum of all the values stored in S .

(6 Marks)

2. (a) Consider the following recursive algorithm:

```
Algorithm  $Q(n)$ 
  if ( $n == 0$  or  $n == 1$ )
    return 1
  else
    return  $Q(n-2) + n + 1$ 
```

Set up a recurrence relation for the number of additions made by the algorithm and solve it.

(7 Marks)

- (b) An integer is stored in each node of a doubly-linked list which has a reference $start$ that points to the first node of the list. Write an algorithm that deletes the node which stores the last occurrence of a given integer k from the list.

(8 Marks)

Note: Question No. 2 continues on page 3.

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- (c) Consider the AVL tree in Figure 1.
- Show the steps taken to balance the tree when a node with value 40 is inserted.
 - Show the steps taken to balance the tree when a node with value 75 is inserted in the balanced tree in part (i).

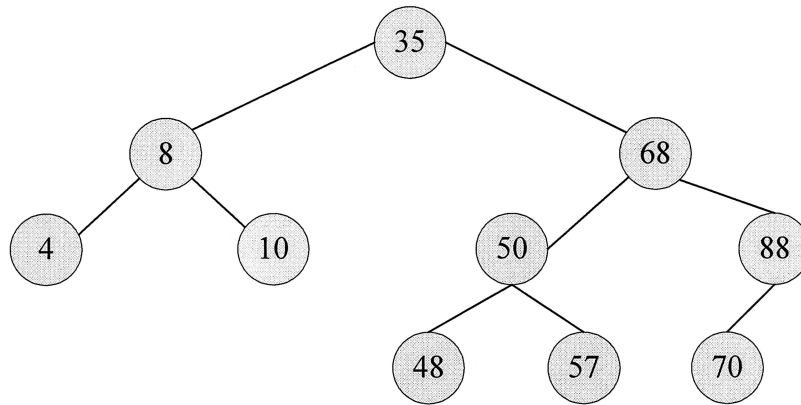


Figure 1

(10 Marks)

3. (a) Consider the following maxheap.

95	67	80	30	28	75	78	15	20	10	8	70
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Explain and show clearly what the array looks like in each step if you are required to perform the following operations:

- delete the fourth element of the array while maintaining the maxheap structure;
- then delete the third element of the array while maintaining the maxheap structure.

(10 Marks)

- (b) Explain and show how to perform radix sort on the following sequence:

74856, 26982, 43982, 26938, 45234, 52313

(7 Marks)

- (c) Write an algorithm in pseudocode to determine the number of leaf nodes of a maxheap with value less than x.

(8 Marks)

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4. (a) Consider the weighted graph in Figure 2. Explain and show clearly each step to find the shortest path from node A to node H.

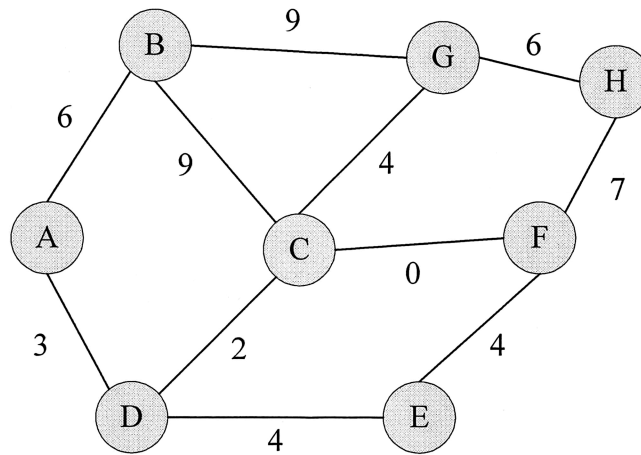


Figure 2

(12 Marks)

- (b) Suppose that a factory manufactures a product that consists of 5 components, which are assembled together. The components need to be assembled according to the following priority:
- Component 1 can only be assembled after component 2.
 - Component 3 can only be assembled after components 1 and 2.
 - Component 4 can only be assembled after components 2 and 3.
 - Component 5 can only be assembled after components 1 and 4.

Explain clearly how you will use depth first search to come up with a sequence to assemble the 5 components correctly.

(8 Marks)

- (c) Given a weighted graph whose edge weights are all non-negative, one wishes to find a shortest path from a source node to a destination node. Professor X claims that one can use Prim's algorithm starting at the source node to find a shortest path to the destination node. Is this claim true or false? Justify your answer.

(5 Marks)

END OF PAPER

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Please read the following instructions carefully:

- 1. Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**
2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.
3. Please write your Matriculation Number on the front of the answer book.
4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.