UNIVERSITY OF SOUTHAMPTON COMP1201W1

SEMESTER 2 EXAMINATION 2014/2015

ALGORITHMICS

Duration: 120 mins

You must enter your Student ID and your ISS login ID (as a cross-check) on this page. You must not write your name anywhere on the paper.

Student ID:	
ISS ID:	

Question	Marks
1	
2	
3	
4	
Total	

Answer all parts of the question in section A (25 marks) and TWO *questions from section B (30 marks each).*

This examination is worth 85%. The tutorials were worth 15%.

University approved calculators MAY be used.

A foreign language translation dictionary (paper version) is permitted provided it contains no notes, additions or annotations.

Each answer must be completely contained within the box under the corresponding question. No credit will be given for answers presented elsewhere.

You are advised to write using a soft pencil so that you may readily correct mistakes with an eraser.

You may use a blue book for scratch—it will be discarded without being looked at.

 Number of pages 14

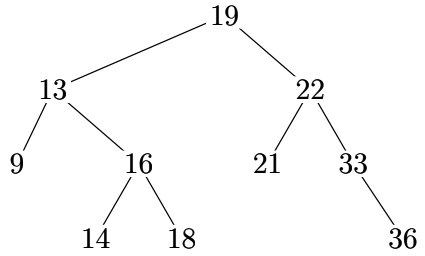
Section A

Question A 1

(a) Draw the binary search tree produced when inserting 57, 90, 13, 9, 50, 43, 55, 82, 56, 51. *(2 marks)*

2

(b) Draw the tree obtained by deleting 22 from the binary search tree shown. *(2 marks)*




```
delete(22)
```

2

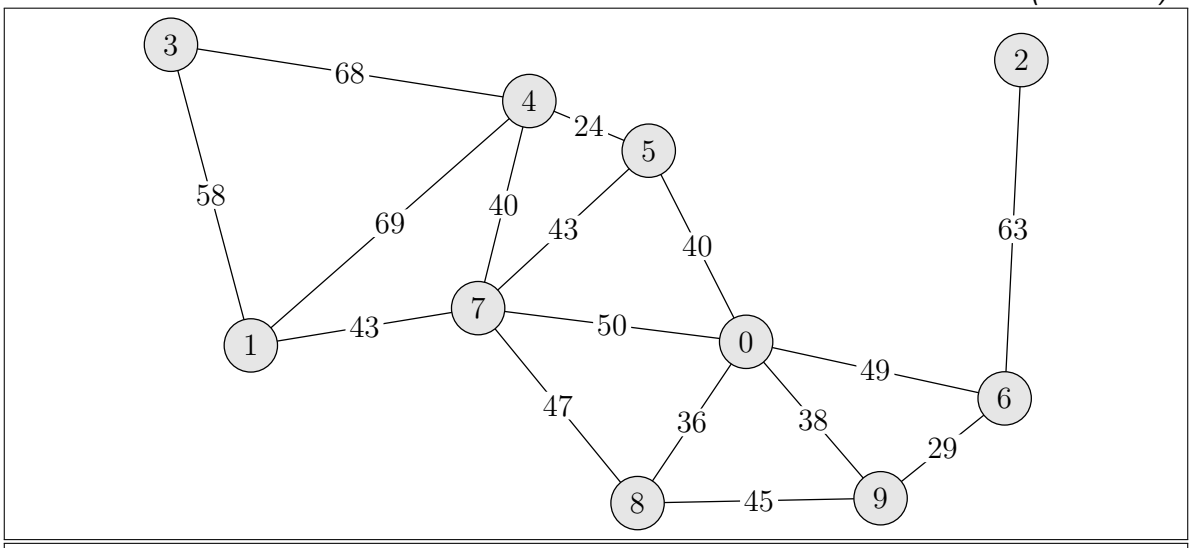
(c) What type of binary search tree is used in the java TreeSet? *(1 marks)*

1

(d) When would you prefer to use a set rather than a list and the vice versa? *(3 marks)*

3

(e) Show the tree of edges found by Dijkstra's algorithm from node 0 and write down the order of the edges and the distance of the node to the source node. *(7 marks)*



7

1.	2.	3.
4.	5.	6.
7.	8.	9.

(f) Heaps use a binary tree encoded into an array. Show the binary tree represented by the following array.

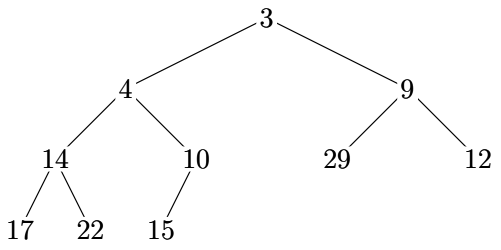
4	19	9	19	20	22	15	24	27	22

(1 marks)

1

(g) Show what happens to the heap shown on the left when you add 2. *(2 marks)*

Before

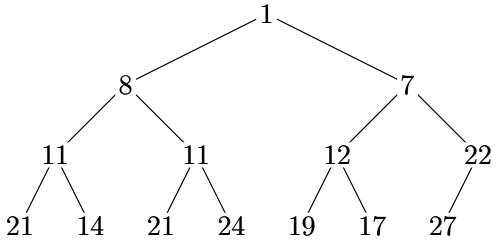


After `add(2)`

2

(h) Show what happens to the heap shown on the left when you remove the minimum entry. *(2 marks)*

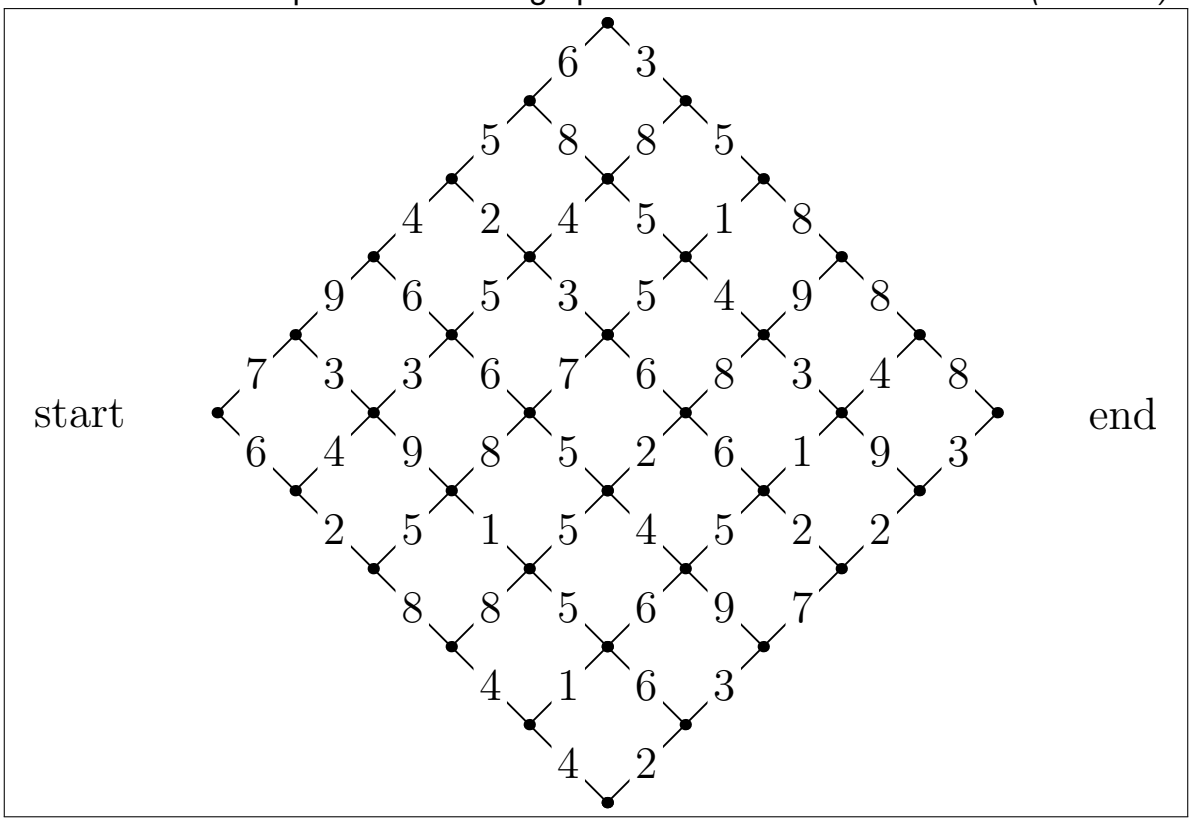
Before



After `removeMin()`

2

(i) Use the dynamic programming forward algorithm to compute the minimum cost of each path from the left most node to each other node where the cost of moving along an edge is equal to the number shown. An edge can only be traversed from left to right. Use the backwards algorithm to find the minimum cost path across the graph. *(5 marks)*



5

End of question 1

Q1: (a) $\frac{}{2}$ (b) $\frac{}{2}$ (c) $\frac{}{1}$ (d) $\frac{}{3}$ (e) $\frac{}{7}$ (f) $\frac{}{1}$ (g) $\frac{}{2}$ (h) $\frac{}{2}$ (i) $\frac{}{5}$ Total $\frac{}{25}$

Section B

Question B 2

(a) What is the main application of B-Trees? *(1 marks)*

1

(b) Describe what problem B-Trees solve and how they solve it. *(3 marks)*

3

(c) Sketch a B-Tree. *(6 marks)*

6

(d) What is a trie or digital tree *(3 marks)*

3

(e) What is (1) the advantage and (2) disadvantage of using a trie compared with a binary search tree? *(2 marks)*

1

2

2

(f) Show how the following words would be inserted into a trie based on tables *(10 marks)*

Add words: {BIN, BINARY, MAP, MAPPER, MAPPERS, MAPS, OTHER, SET, SETTER, THAT, THE, THIS, TREE}

	0	1	2	3	4	5	6
$							
A							
B							
C							
D							
E							
I							
L							
M							
N							
O							
P							
R							
S							
T							
U							

10

(g) Write down all the suffixes of the word "**queues**" and draw the suffix tree for the word. *(5 marks)*

5

End of question 2

Q2: (a) $\frac{}{1}$	(b) $\frac{}{3}$	(c) $\frac{}{6}$	(d) $\frac{}{3}$	(e) $\frac{}{2}$	(f) $\frac{}{10}$	(g) $\frac{}{5}$	Total $\frac{}{30}$

Question B 3

The quicksort algorithm is as follows

```
QuickSort(a, left, right) {
  if (right-left < threshold)
    InsertionSort(a, left, right)
  else
    pivot = ChoosePivot(a, left, right)
    part = Partition(a, pivot, left, right)
    QuickSort(a, left, part)
    QuickSort(a, part+1, right)
  endif
}
```

(a) Describe the ChoosePivot algorithm for finding a pivot. *(3 marks)*

3

(b) How does the Partition algorithm work? *(5 marks)*

5

(c) Explain why quicksort uses INSERTIONSORT? *(3 marks)*

3

(d) Assume that PARTITION takes n operations and that the pivot splits the array exactly in half at each step (assume also that the `threshold` equals 1). Write a recursion relations for the number of partitioning operations, $T(n)$. *(4 marks)*

T(n) =

4

(e) Show that $T(n) = n \log_2(n)$ satisfies the recursion relation in part (d). *(4 marks)*

4

(f) Assume that PARTITION takes n operations and that the pivot splits the array into an array of size $n - 1$ and another array of size 1. Write a recursion relations for the number of partitioning operations, $T(n)$. *(4 marks)*

T(n) =

4

(g) Show that if $T(1) = 0$ then the time complexity, $T(n)$, of quicksort (given the unlucky partitioning described in part (f)) is equal to the function $f(n) = n(n+1)/2 - 1$. *(4 marks)*

$\overline{4}$

(h) Give the worst case complexity for quicksort and explain why this does not put off people using it. *(3 marks)*

$\overline{3}$

End of question 3

Q3: (a) $\overline{3}$	(b) $\overline{5}$	(c) $\overline{3}$	(d) $\overline{4}$	(e) $\overline{4}$	(f) $\overline{4}$	(g) $\overline{4}$	(h) $\overline{3}$	Total $\overline{30}$

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Question B 4

(a) Which of the following algorithms are in class P and which are in class NP-complete *(5 marks)*

(i) TSP:

(ii) Minimum Spanning Tree:

(iii) Maximum Flow:

(iv) Graph Colouring:

(v) Linear Assignment:

5

(b) Describe what it means to be class NP-complete. *(5 marks)*

5

(c) Describe neighbourhood search and explain how it could be used to find a good solution to an optimisation problem. *(5 marks)*

5

(d) Briefly describe simulated annealing and why it is used. *(5 marks)*

5

(e) Briefly describe branch and bound and its expected performance. *(5 marks)*

15

(f) Briefly describe how dynamic programming can be used to solve TSP and describe its time complexity *(5 marks)*

15

End of question 4

Q4: (a) $\frac{}{5}$	(b) $\frac{}{5}$	(c) $\frac{}{5}$	(d) $\frac{}{5}$	(e) $\frac{}{5}$	(f) $\frac{}{5}$	Total $\frac{}{30}$