

Questionnaire

Algorithms and Datastructure

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Spring 2017

The questionnaire is mandatory!

The time of the questionnaire is Wednesday 24th 13:00-16:00.

The aim of the questionnaire is to test your skills broadly in the curriculum. The result of the questionnaire will be the foundation of the oral exam. It is not possible to fail the exam alone on the results of the questionnaire.

You can use your computer and the internet, but not for communicating with others. Consequently you cannot use services as Facebook or Messenger, so please close these services during the test.

The answer shall be handed in on paper.

Full name:

Anders Kalhauge

Number of additional pages _____

Big O

- 1 Determine the time complexity with respect to n of the following methods

Use Big O in your answer

- Execution time is the same for any value of n , even though 10.000 iterations are done.
- 1.1 The sqrt operation does not depend on n

```
double q1(int n) {  
    double r = 0.0;  
    for (int i = 0; i < 10000; i++) {  
        r = Math.sqrt((double)n/i);  
    }  
    return r;  
}
```

$O(1)$

- 1.2 Exactly $n-1$ iterations are done

```
double q2(int n) {  
    double r = 0.0;  
    for (int i = 1; i < n; i++) {  
        r += Math.log(i);  
    }  
    return r;  
}
```

$O(n-1) = O(n)$

Problem is halved at every iteration

- 1.3

```
double q3(int n) {  
    double r = 0.0;  
    while (n > 1) {  
        r += Math.log(n);  
        n = n/2;  
    }  
    return r;  
}
```

$O(\log n)$

Even though j only iterates from i to n it makes roughly $\frac{n \cdot n}{2}$ iterations

```
1.4 static double q4(int n) {
    int r = 0;
    for (int i = 0; i < n; i++) {
        for (int j = i; j < n; j++) {
            r++;
        }
    }
    return r;
}
```

$$O\left(\frac{n^2}{2}\right) = \underline{\underline{O(n^2)}}$$

2 Identify the time complexity

with respect to n for an algorithm with the running time as

n	time
125	0,03s
1.000	1,00s
8.000	32,00s
64.000	1.024,00s
512.000	32.768,00s

This assignment is
too hard !-)
but the answer is
 $O(n^{\frac{5}{3}})$

Beware! This question is not trivial

3 Give the order of growth

of the running time for the following algorithms in the special case where they should sort a list in reverse order¹:

- | | |
|--------------------|---------------------------------------|
| 3.1 Quick Sort | $O(n^2)$ - it is worst case scenario! |
| 3.2 Insertion Sort | $O(n^2)$ |
| 3.3 Heap Sort | $O(n \log n)$ |
| 3.4 Selection Sort | $O(n^2)$ |

¹as (99, 56, 45, 32, 13, 9, 7)

Sorting

4 Match the sorting algorithms

The following list is unsorted:

47	14	39	26	31	42	12	55	17	33
----	----	----	----	----	----	----	----	----	----

find the algorithm, that partially sorted the lists below. In other words, which algorithm has started sorting, but is not yet finished: green cells are sorted, red cells are moved

4.1

12	14	39	26	31	42	47	55	17	33
----	----	----	----	----	----	----	----	----	----

Selection sort

12	14	39	26	31	42	47	55	17	33
----	----	----	----	----	----	----	----	----	----

12	14	17	26	31	42	47	55	39	33
----	----	----	----	----	----	----	----	----	----

4.2

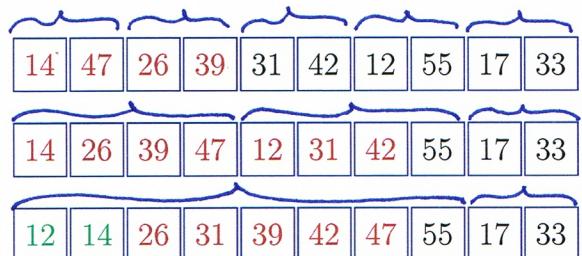
47	14	39	26	31	42	12	55	17	33
----	----	----	----	----	----	----	----	----	----

Insertion sort

14	47	39	26	31	42	12	55	17	33
----	----	----	----	----	----	----	----	----	----

14	39	47	26	31	42	12	55	17	33
----	----	----	----	----	----	----	----	----	----

4.3



Merge sort
bottom-up

Candidates are Quick Sort, Insertion Sort, Selection Sort, Merge Sort, and Heap Sort

Searching

5 What is the difference

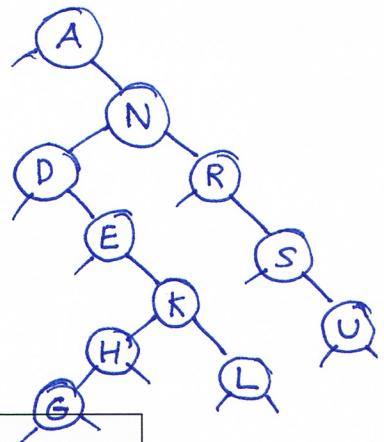
between binary search in an ordered array and in a binary tree

6 Draw a binary search tree

of the letters in your full name

7 Find the maximum

```
class BinaryTree<T extends Comparable> {
    private T data;
    private BinaryTree<T> smaller;
    private BinaryTree<T> larger;
    ...
    public T maximum() {
        // maximum code goes here ;)
        if (larger == null) return data;
        return larger.maximum();
    }
}
```



Fill in the missing code in the `maximum` method.

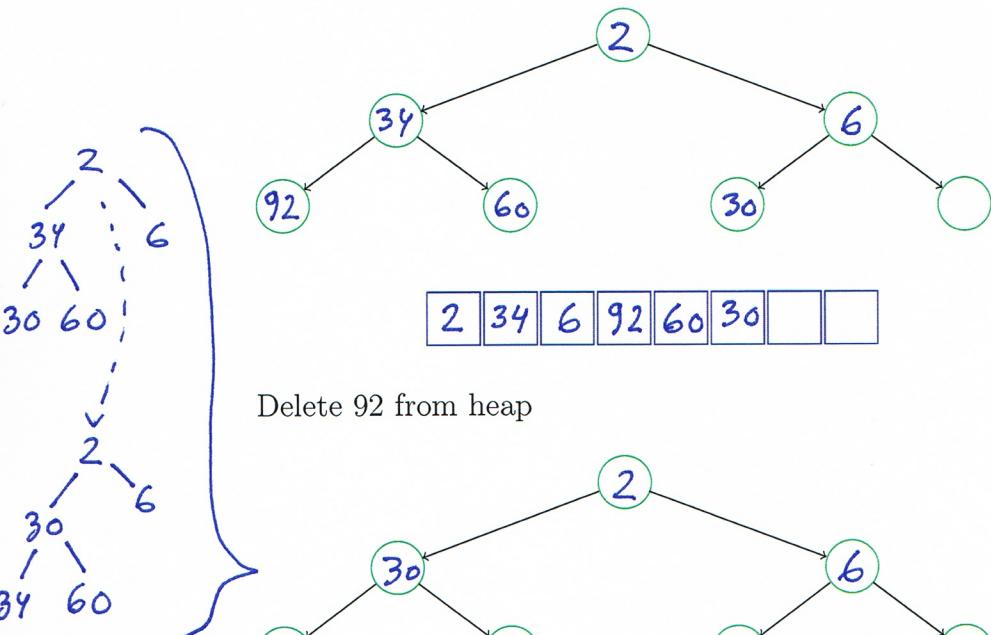
8 What is a B-tree

What is a B-tree data structure, what are the advantages/disadvantages compared to classic binary search trees?

Queueing

9 Heaps

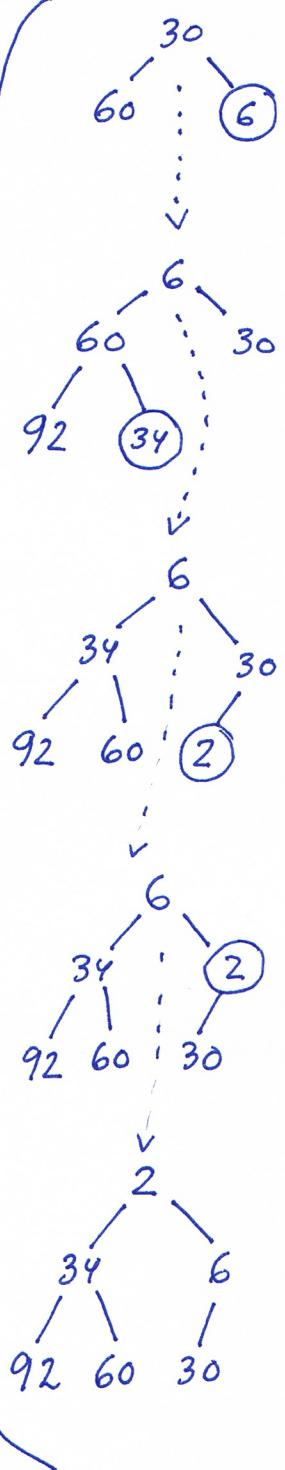
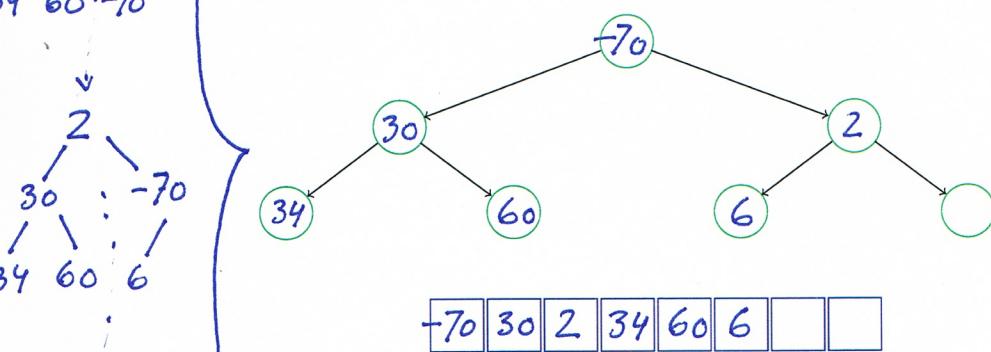
Present the following input (30, 60, 6, 92, 34, 2) in a min heap.



Delete 92 from heap



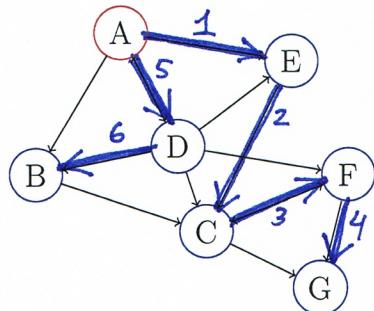
Add -70 to the heap



Graphs

10 Iterative Depth-first traversal

Show the iterative depth-first traversal from node 'A' on the graph below:

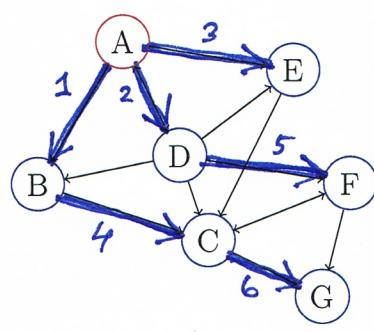


1	A-B	A-D	<u>A-E</u>
2	A-B	A-D	<u>E-C</u>
3	A-B	A-D	<u>C-G</u> <u>C-F</u>
4	A-B	A-D	C-G <u>F-G</u>
5	A-B	<u>A-D</u>	
6	A-B	<u>D-B</u>	

Show the changes in the stack and sequence (number the edges) of traversal.

11 Iterative Breadth-first traversal

Show the iterative breadth-first traversal from node 'A' on the graph below:



1	<u>A-B</u>	A-D	A-E
2	<u>A-D</u>	A-E	B-C
3	<u>A-E</u>	B-C	D-C D-F
4	<u>B-C</u>	D-C	D-F E-C
5	<u>D-F</u>	E-C	C-G C-F
6	<u>C-G</u>	C-F	

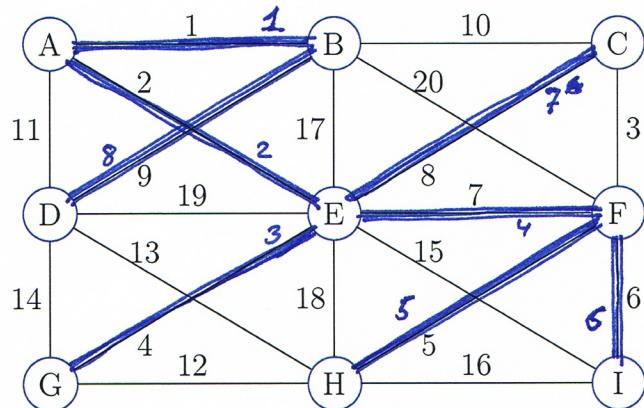
Show the changes in the queue and sequence (number the edges) of traversal.

$$V = \{A, B, C, D, E, F, G, H, I\}$$

$$E = \{(A, B, 1), (B, C, 10), (A, D, 11), \dots\}$$

12 Minimum spanning tree

Given the graph:

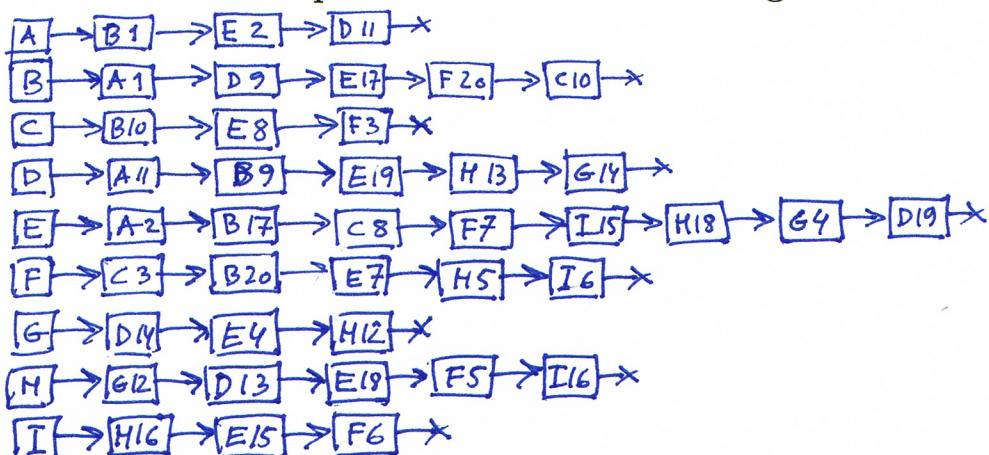


12.1 Find the minimum spanning tree

Argue for the algorithm used.

12.2 Write edges and vertices as sets

12.3 Sketch implementation with an edge list



What would be the time complexity (big O) of finding adjacent nodes?

$O(1)$

Just look it up⁹
and you have the list

For finding if
two specific vertices
are connected

$O(n)$

12.4 Sketch implementation with an adjacency matrix

	A	B	C	D	E	F	G	H	I
A	1		11	2					
B	1	10	9	17	20				
C		10		8	3				
D	11	9		19		14	13		
E	2	17	8	19		7	4	18	15
F	20	3		7			5	6	
G			14	4			12		
H			13	18	5	12		16	
I				15	6		16		

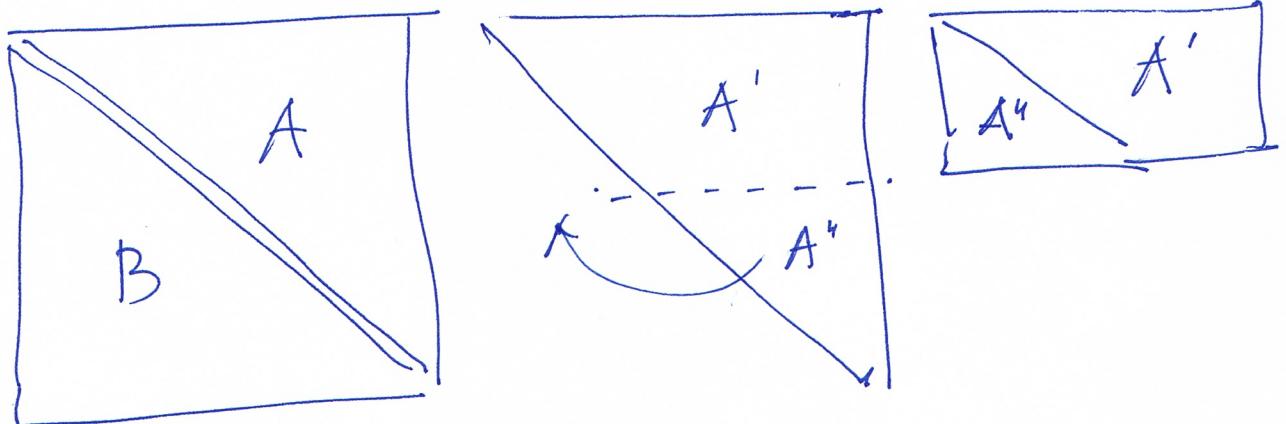
$O(n)$ You have to look in all cells in a row to find all connected vertices

$O(1)$ For testing if two specific vertices are connected.

What would be the time complexity (big O) of finding adjacent nodes?

Can you optimize the data structure?

While the graph is undirected, values are mirrored in the areas A and B



Texts

13 What is an Alphabet

*finite set of characters
perfect hashable*

What are the properties of an alphabet?

14 Write a perfect hash function

The rooms in Cphbusines have codes like CL-1.03 and CS-2.02. The second letter can be one of the following: B, C, H, L, N, or S²

14.1 Deduce the alphabet

$\Sigma = \{ 'B', 'C', 'H', 'L', 'N', 'S',$
 $'-', '.', '0', '1', '2', '3', '4', '5', '6', '7',$
 $'8', '9' \}$

What is the alphabet needed to identify a room at Cphbusiness?

14.2 Write a perfect hash function

of the alphabet

```
public int indexOf(char letter) {  
    // Perfect hash code goes here :-)  
    if ('0' <= letter && letter <= '9') return letter - '0';  
    switch (letter) {  
        case '-': return 10;  
        case '.': return 11;  
        case 'B': return 12;  
        :  
        case 's': return 17;  
    }  
}
```

15 Write a Regular Expression

$C [BCHLNS]-[0-9]\.[0-9]\{2\}$

that describes the room codes described above!

²Bornholm, City, Hillerød, Lyngby, Nørrebro, or Søerne