

UNIVERSITY OF BIRMINGHAM

School of Computer Science

First Year Undergraduate

06-30175

30175 LC Data Structure & Algorithms

Resit Examinations 2022

[Answer all questions]

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Note

Answer ALL questions. Each question will be marked out of 20. The paper will be marked out of 60, which will be rescaled to a mark out of 100.

Question 1

- (a) Write the missing pseudocode in the code below of an efficient recursive method to print, in order, all values in a Binary Search Tree of integers that fall within the inclusive range [min, max]

Assume the method `print(int val)` will print a value and that if `t` is a `BSTNode`, then `t.left`, `t.val` and `t.right` allow access to the left, val and right fields of the node.

```
1 void printRange(BSTNode t, int min, int max)
2 {
3     // WRITE THE CODE THAT SHOULD BE HERE
4     return
5 }
```

[10 marks]

- (b) The standard algorithm for deleting a node from a binary search tree can be described as follows:

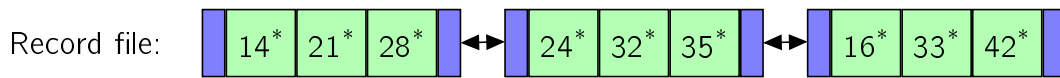
```
1: find the node containing the value to be deleted
2: if it is a leaf {
3:     remove it
4: }
5: else if only one of its children is not empty {
6:     replace the node with the root of the non-empty subtree
7: }
8: else {
9:     find the left-most node in the right sub-tree
10:    replace the value to be deleted with that of the left-most node
11:    replace the left-most node with its right child
12: }
```

Explain, in detail, why the complexity of this operation is $O(\log n)$ if the tree is balanced.

[10 marks]

Question 2

- (a) Assume an external record file, where each record can contain up to 3 records, is stored on secondary storage as follows (with record block pointers as indicated and records shown as n^* for a record with key value n):



Construct a Secondary Index B+Tree on this record file and present your results as a **single** diagram, showing all secondary storage pointers, blocks and block contents for all of the B+Tree and record file blocks. Assume that the B+Tree blocks can hold a maximum of 3 key values.

[10 marks]

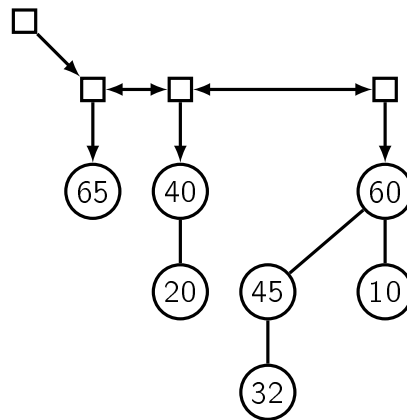
- (b) Assume you have a list of records, each with two fields (X, Y), where X is an integer field and Y is a character field. Explain, showing intermediate steps, how Binsort sorts this list so that it results in all the records sorted by the X field first and then by the Y field for groups of records with the same X value. Use the following list of records in the given order for your demonstration (draw contents of Queues as lists with the head of the list to the left)

$[(2, c), (1, b), (3, a), (3, c), (1, a), (2, a), (2, b), (3, b), (1, c)]$

[10 marks]

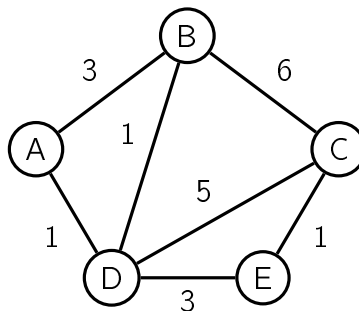
Question 3

- (a) Draw a diagram of the result of inserting the value **55** into the following Binomial Heap, where the highest priority is the highest integer value, and explain the steps by which you came to your result.



[10 marks]

- (b) Consider the following graph:



Demonstrate the execution of the Dijkstra algorithm for finding the minimal path on this graph from node A to node C, by writing out a table of the execution steps in the following format where the first row, following initialisation, is already provided:

A	B	C	D	E	Finished
0, A	∞ , B	∞ , C	∞ , D	∞ , E	
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

Each row should show the results of one iteration of the algorithm, where the *Finished* column identifies the node that is finished in that iteration, and the remaining columns show the current shortest distance of the node of that column from node A, the previous node to the node of this column on the current shortest path from A and a tick mark if the node of the column is finished. Finally, explain how the shortest path, and its length, can be read from the final line of the table on completion of the algorithm.

[10 marks]