SEMESTER 2
2021-2022

CS211FZ
Algorithms and Data Structures 2

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Time allowed: 2 hours

Answer at least ***four*** questions
Your mark will be based on your best ***four*** answers

All questions carry equal marks

Instructions

	Yes	**No**
Log Books Allowed		X
Formula Tables Allowed		X
Other Allowed (*enter details)*		X

General (*enter detail)*

QUESTION 1 (25 marks)

(a) Given an empty Red-Black tree, show how the tree is updated after inserting each value listed below. (Use Circle shape to indicate a RED node and Square shape to indicate a BLACK node.) (10 marks)

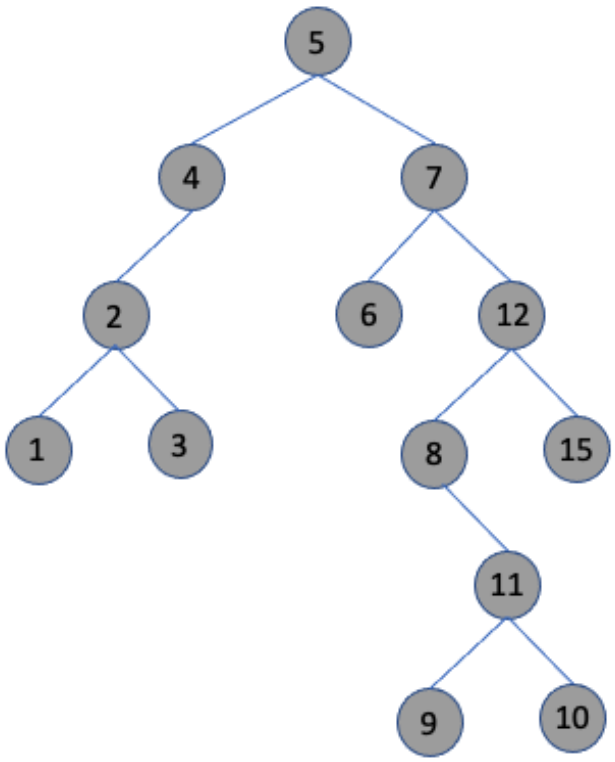
16, 8, 24, 4, 12, 6, 7

(b) Given a string as shown below, construct a Huffman tree for the following string and calculate the average number of bits needed to encode each symbol in the string based on Shannon's Information Entropy. (15 marks)

ABBACADA

QUESTION 2 (25 marks)

(a) Given a binary search tree as shown the figure below,



(i) write a recursive method for traversing all nodes of the tree in inorder traversal. (6 marks)

(ii) show the order of nodes visited from a post-order traversal. (4 marks)

(b) The following code fragment implements the merge sort algorithm that can be used to sort integer numbers. Complete the implementation for the ***merge*** method. (15 marks)

```
void mergeSort(int[] data, int left, int right) {
    if (left < right) {
        int centre = (left + right) / 2;
        mergeSort(data, left, centre);
        mergeSort(data, centre + 1, right);
        merge(data, left, centre, right);
      }
}
```

QUESTION 3 (25 marks)

(a) Draw the 11-entry hash table that results from using the hash function, h(i)=(3i+5) mod 11, to hash the keys 12, 44, 13, 88, 23, 94, 11, 39, 20, 16, and 5, assuming collisions are handled by quadratic probing, up to the point where the method fails. (15 marks)

(b) What is the result of the previous exercise when collisions are handled by double hashing using the secondary hash function $h'(k) = 7 - (k \bmod 7)$? (10 marks)

QUESTION 4 (25 marks)

Let G be an undirected graph whose vertices are the integers 1 through 8, and let the adjacent vertices of each vertex be given by the table below:

vertex	adjacent vertices
1	(2, 3, 4)
2	(1, 3, 4)
3	(1, 2, 4)
4	(1, 2, 3, 6)
5	(6, 7, 8)
6	(4, 5, 7)
7	(5, 6, 8)
8	(5, 7)

Assume that, in a traversal of G, the adjacent vertices of a given vertex are returned in the same order as they are listed in the table above.

(a) Draw G. (5 marks)

(b) Draw a spanning tree of the graph using a DFS traversal starting at vertex 1. In choosing among adjacent vertices, the vertex with a lower number has higher priority. (10 marks)

(c) Draw a spanning tree of the graph using a BFS traversal starting at vertex 1. In choosing among adjacent vertices, the vertex with a lower number has higher priority. (10 marks)

QUESTION 5 (25 marks)

Bob loves foreign languages and wants to plan his course schedule for the following years. He is interested in the following nine language courses: LAI5, LAI6, LA22, LA31, LA32, LA126, LA127, LA141, and LA169. The course prerequisites are:

- LAI5: (none)
- LAI6: LA15
- LA22: (none)
- LA31: LA15
- LA32: LA16, LA31
- LAI26:LA22, LA32
- LA127: LAI6.
- LA141: LA22, LA16
- LA169: LA32.

(a) Find the sequence of courses that allows Bob to satisfy all the prerequisites. (10 marks)

(b) Describe your solution. (15 marks)