	<p>Student's full name:</p> <p>Students' code:</p> <p>Student's class:</p>	
<p>DATA STRUCTURES</p> <p>Date: 20 April, 2021</p> <p>Duration: 120 minutes</p>	<p align="center">FINAL EXAMINATION</p>	
	<p align="center"><u>Invigilator 1</u></p>	<p align="center"><u>Invigilator 2</u></p>

- Writing test consists of **6 PAGES** (*Answer Sheet included*).
- Students are required to use provided **blue-color** pens to write responses.
- Learning materials, dictionaries and any kinds of electronic devices are **NOT** allowed during the test time.



Student Full Name:

HCMUS Student ID:

Student's class:

**FINAL EXAMINATION
ANSWER SHEET**

Result	Examiners

Given list A of integer numbers below:

22, 1, 13, 11, 24, 33, 18, 42, 31, 32

Question 1. BINARY SEARCH TREE

Consider a balanced binary search tree AVL.

- a. *(1 point)* Draw the AVL tree step-by-step with the keys from list A above in the exact order:

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- b. (0.5 point) What is the post-order traversal (**LRN**) result of the tree in question 1a?

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- c. (0.5 point) From the tree in question 1a, delete the node with key **24**. What is the resulting tree?

Notice: if you delete a two-child node, the replacing node is the node with the biggest key of the subtree to the left.

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- d. (0.75 point) Write a function that prints the keys of the **leaf nodes** that contain an **even value**.

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Question 2. SORTING ALGORITHMS

- a. (1 point) Indicate the result of **MAX-HEAP creation** from list A above.

- b. (1 point) Demonstrate step-by-step the process of first partitioning list A above into 2 parts using Quick Sort algorithm for **descending sorting** with a **pivot element of 32**.

[illegible]

Question 3. HASH TABLE

Initialize an empty hash table of $m = 12$ elements. Given a hash function $h(k) = k \bmod 12$, provide the result of the hash table after adding keys from list A above in the exact order.

In case of a collision, resolve by:

- a. (1 point) Quadratic probing

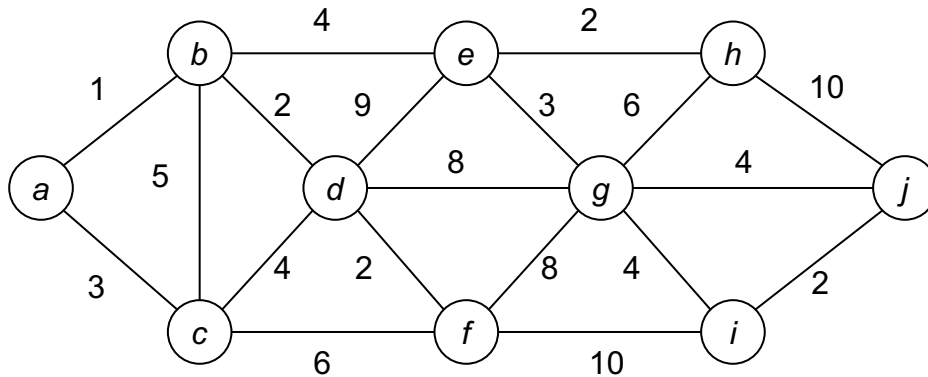
0	1	2	3	4	5	6	7	8	9	10	11

- b. (1 point) Double hashing with a second hash function $h_2(k) = [k \bmod (m-2)] + 1$

0	1	2	3	4	5	6	7	8	9	10	11

Question 4. GRAPH

Given a graph (G) below:

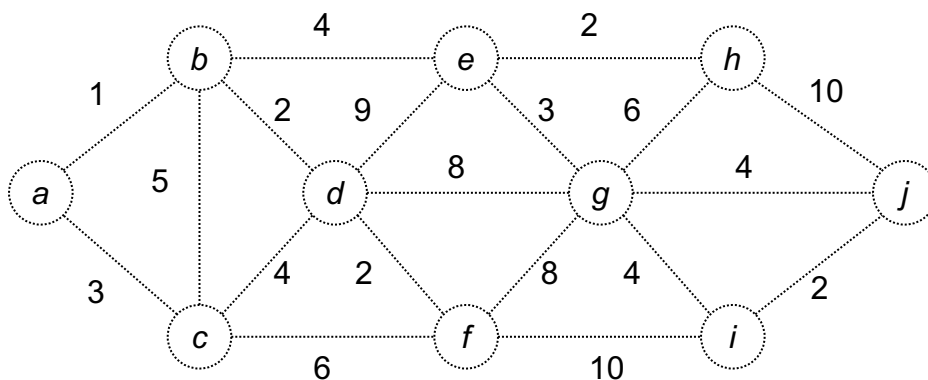


- a. (1 point) List the edges of (G) in the exact order to be inserted into a **minimum spanning tree** using **Prim's algorithm**.

#	Edge	Weight
1		
2		
3		
4		
5		

#	Edge	Weight
6		
7		
8		
9		
10		

- b. (0.25 point) Draw the minimum spanning tree from the result of question 4a.



- c. (0.25 point) Provide the **total weight** of the minimum spanning tree of graph (G)

Total weight of minimum spanning tree:

- d. (1 point) Demonstrate step-by-step the process of finding the shortest path **from a to j** in graph (G) above using **Dijkstra's algorithm**.

	a	b	c	d	e	f	g	h	i	j
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

- e. (0.5 point) Provide **the shortest path from a to j** from the result of question 4d.

- f. (0.25 point) Provide the **total cost** of the shortest path above

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