CSCI2100D 2023-24: Assignment 2*

[#] This assignment is due at 11:59:59pm, 6th March 2024.

- **Q1. [16 marks]** Answer the following questions about Stacks.
  - **(i). [8 marks]** Given the postfix expression 2 6 - 5 * 1 4 + /, show how to use a stack to calculate the final results. Please show the stack status step by step (Hint. You may follow the steps as shown in `CSCI2100D-Lectures-9-Stack-Queue`).
  - **(ii). [8 marks]** Use a stack to check if the symbol list [{ ( ) }] [( ]) is balanced. Show the stack status after each symbol checking (Hint. You may follow the steps as shown in `CSCI2100D-Lectures-9-Stack-Queue`).
- **Q2. [10 marks]** Answer the following questions about Queues.
  - **(i). [5 marks]** Assume that we have an empty queue Q. Given a series of queue operations on Q as below, write down the element returned by each DEQUEUE operation and show the final queue.
    - ENQUEUE$(Q, 1)$, ENQUEUE$(Q, 3)$, DEQUEUE(Q), ENQUEUE$(Q, 2)$, ENQUEUE$(Q, 5)$, DEQUEUE(Q), DEQUEUE(Q), ENQUEUE$(Q, 4)$, DEQUEUE(Q).
  - **(ii). [5 marks]** Suppose that we use a circular queue, what is the minimum size required to support the above series of queue operations? If the value of front is initially set to 0, what will the final values of the front and rear be?
- **Q3. [30 marks]** Answer the following questions about Trees.
  - **(i) [7 marks]** Suppose we have a binary tree T_1. The inorder traversal sequence and postorder traversal sequence of T_1 are given below. Please draw the tree out and also give the preorder traversal sequence of T_1.
    - Inorder traversal sequence of T_1: d, f, a, b, c, g, e
    - Postorder traversal sequence of T_1: d, a, f, c, e, g, b
  - **(ii). [8 marks]** Given a binary tree T_2 as shown in Fig. 1, is T_2 a max heap? Justify your answer. Next, write down the array representation of the binary tree T_2. Please fill the values in the array as shown below.

[1]	**[2]**	**[3]**	**[4]**	**[5]**	**[6]**	**[7]**	**[8]**	**[9]**	**[10]**	**[11]**	**[12]**	**[13]**

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- **(iii). [15 marks]** Design an algorithm in pseudo-code to find the maximum of **leaf nodes** in a binary tree. Your algorithm should use the following Binary Tree ADT operations. For example, the maximum of all leaf nodes of the binary tree T_2 shown in Fig. 1 is 46.
  You must ensure that your algorithm will not throw ERROR in any case.

  Binary Tree **ADT**
  - `Create():` Return an empty binary tree.
  - `MakeBT(bintreeL,element,bintreeR):` Return a binary tree whose left subtree is **bintreeL** and right subtree is **bintreeR**, and whose root node contains the data **element**.
  - `IsEmpty(bintree):` If **bintree** is empty return TRUE else return FALSE.
  - `Lchild(bintree):` If **bintree** is empty *throw* ERROR else return the left subtree of **bintree**.
  - `Rchild(bintree):` If **bintree** is empty *throw* ERROR else return the right subtree of **bintree**.
  - `Data(bintree):` If **bintree** is empty *throw* ERROR else return the element data stored in the root node of **bintree**.

- **Q4. [18 marks]** Answer the following questions about the Heap.
  - **(i). [9 marks]** Given the max heap H as shown in Fig. 2, show the procedure of inserting 47 into the max heap step by step (Hint. You may follow the steps as shown in `CSCI2100D-Lectures-11-12-BinaryTreeADT-and-Heap`).
  - **(ii). [9 marks]** Given a max heap H as shown in Fig. 2, show the procedure of heap delete operation on the max heap step by step (Hint. You may follow the steps as shown in `CSCI2100D-Lectures-11-12-BinaryTreeADT-and-Heap`).

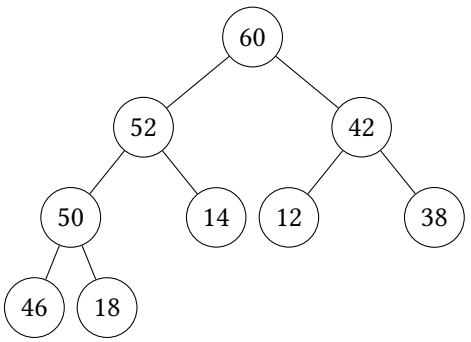

Fig. 1. A Binary Tree T_2 for Q3

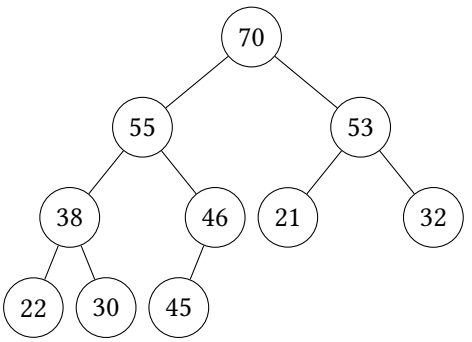

Fig. 2. A Max Heap H for Q4

- **Q5. [18 marks]** Answer the following questions about the Binary Search Tree. (Hint. You may follow the steps as shown in `CSCI2100D-Lectures-13-Binary-Search-Tree`).

- **(i). [4 marks]** Given a binary search tree T_3 as shown in Fig. 3, show the nodes examined when searching for 85.
- **(ii). [7 marks]** Given a binary search tree T_3 as shown in Fig. 3, draw the binary search tree after inserting 26, 42 in order.
- **(iii). [7 marks]** Given a binary search tree T_3 as shown in Fig. 3, draw the binary search tree after deleting 81, 54 in order.

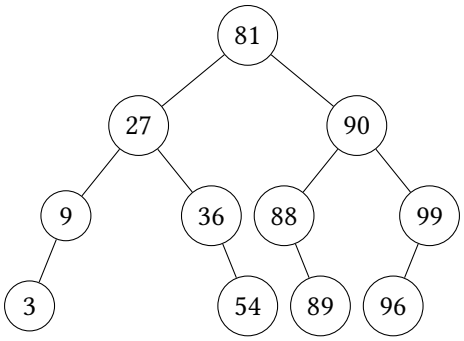

Fig. 3. A Binary Search Tree T_3 for Q5

- **Q6. [8 marks]** In computer science, a trie is a tree data structure to locate specific keys within a set. These keys are most often strings, with links between nodes defined are individual characters. In order to access a key, the trie is traversed depth-first, following the links between nodes, which represent each character in the key.
  Though tries can be keyed by character strings, they need not be. In real-world computer architectures, integers are typically represented in binary using a fixed number of bits. For example, representing 24 in binary with 6 bits would be 011000. Therefore, we can also use a binary trie to store a set of integers. The root node represents an empty binary string. Starting from the most significant bit, each node's left child represents the next bit being 0, and its right child represents the next bit being 1 in the binary representation. Fig. 4 shows a trie T_4 which maintains a set containing 0, 3, 5, 6 represented in 3-bit binary.

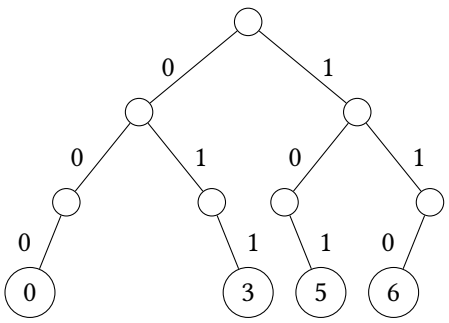

Fig. 4. A Trie T_4 maintains a set containing 0, 3, 5, 6

- **(i). [4 marks]** Draw a trie to maintain the set containing 1, 7, 12, 20, 24, 32, 63 represented in 6-bit binary.
- **(ii). [4 marks]** Suppose you have a trie maintains a set containing several integers represented in D-bit binary. Can you design an algorithm to find the largest element in this set that is not greater than the input k in O(D) time? Please introduce your design idea briefly.