CSE 4304-Data Structures Lab. Winter 2022-23
Batch: CSE 21
Lab: 10
Date: October 23, 2023.
Target Group: All
Topic: AVL Trees, Trie

Instructions:

- You must submit the solutions in the Google Classroom despite finishing the lab tasks within lab time. If I forget to upload the tasks there, CR should contact me. The deadline will always be 11:59 PM on the day the lab has occurred.
- Task naming format: fullID_T01L07_2A.c/cpp.
- If you find any issues in the problem description/test cases, comment in the Google Classroom.
- If you find any tricky test case that I didn't include, but others might forget to handle, please comment! I'll be happy to add.
- Use appropriate comments in your code. This will help you to easily recall the solution in the future.
- Obtained marks will vary based on the efficiency of the solution.
- Do not use <bits/stdc++.h> library.
- Modified sections will be marked with BLUE color.

Group	**Tasks**
2B	1 2 3 4
2A	1 2 3 5
1B	
1A	
Assignment	**The tasks not covered in your lab**

<u>Task-1:</u> Calculating the Balance Factor of different nodes

A series of values are being inserted in a BST. Your task is to show the balance factor of every node after each insertion.

balance_factor= height_of_LeftSubtree - height_of_RightSubtree

The following requirements must be addressed:

- Continue taking input until -1.
- After each insertion, print the nodes of the tree in an in-order fashion. Show the balance_factor beside each node within a bracket.
- Each node has the following attributes: data, left_pointer, right_pointer, parent_pointer, and height. (store balance_factor if needed, but optional)
- Your code should have the following functions:
    - void insertion (key): iteratively inserts a key into the BST.
    - void Update_height(node): update the height of a node after each insertion. Note that only the ancestors are affected after the insertion of a new key.
    - int height(node): returns the height of a node
    - int balance_factor(node): returns balance factor of a node

Sample Input	**Sample Output**
12 8 5 11 20 4 7 17 18 -1	12(0) 8(0) 12(1) 5(0) 8(1) 12(2) 5(0) 8(0) 11(0) 12(2) 5(0) 8(0) 11(0) 12(1) 20(0) 4(0) 5(1) 8(1) 11(0) 12(2) 20(0) 4(0) 5(0) 7(0) 8(1) 11(0) 12(2) 20(0) 4(0) 5(0) 7(0) 8(1) 11(0) 12(1) 17(0) 20(1) 4(0) 5(0) 7(0) 8(1) 11(0) 12(0) 17(-1) 18(0) 20(2)

Task-2: Balancing a BST

Utilize the functions implemented in Task-1 to provide a complete solution for maintaining a 'Balanced BST'. The program should continue inserting values until it gets -1. For each insertion, it checks whether the newly inserted node has imbalanced any node or not. If any imbalanced node is found, 'rotation' is used to fix the issue.

Your program must include the following functions:

- void insertion (key): iteratively inserts a key into the BST.
- void Update_height(node): update the height of a node after each insertion. Note that only the ancestors are affected after the insertion of a new key.
- int height(node): returns the height of a node
- int balance_factor(node): returns the balance factor of a node
- left_rotate(node)
- right_rotate(node)
- check_balance(node): check whether a node is imbalanced and call relevant rotations if needed.
- print_avl(root): print the tree using inorder traversal. The balance factor is printed beside each node.

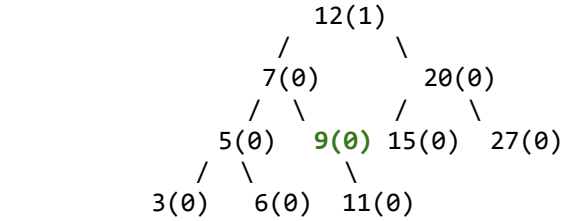
Sample Input	**Sample Output**
12	12(0) Balanced Root=12
9	**9**(0) 12(1) Balanced Root=12
5	5(0) **9**(1) 12(2) Imbalance at node: 12 LL case **right**_rotate(12) Status: 5(0) **9**(0) 12(0) Root=**9**
11	5(0) **9**(-1) 11(0) 12(1) Balanced Root=**9**
20	5(0) **9**(-1) 11(0) 12(0) 20(0) Balanced Root=**9**
15	5(0) **9**(-2) 11(0) 12(-11) 15(0) 20(1) Imbalance at node: **9** RR case Left_rotate(**9**) Status: 5(0) **9**(0) 11(0) 12(0) 15(0) 20(1) Root=12
7	5(-1) 7(0) **9**(1) 11(0) 12(1) 15(0) 20(1) Balanced Root=12
3	3(0) 5(0) 7(0) **9**(1) 11(0) 12(1) 15(0) 20(1) Balanced Root=12

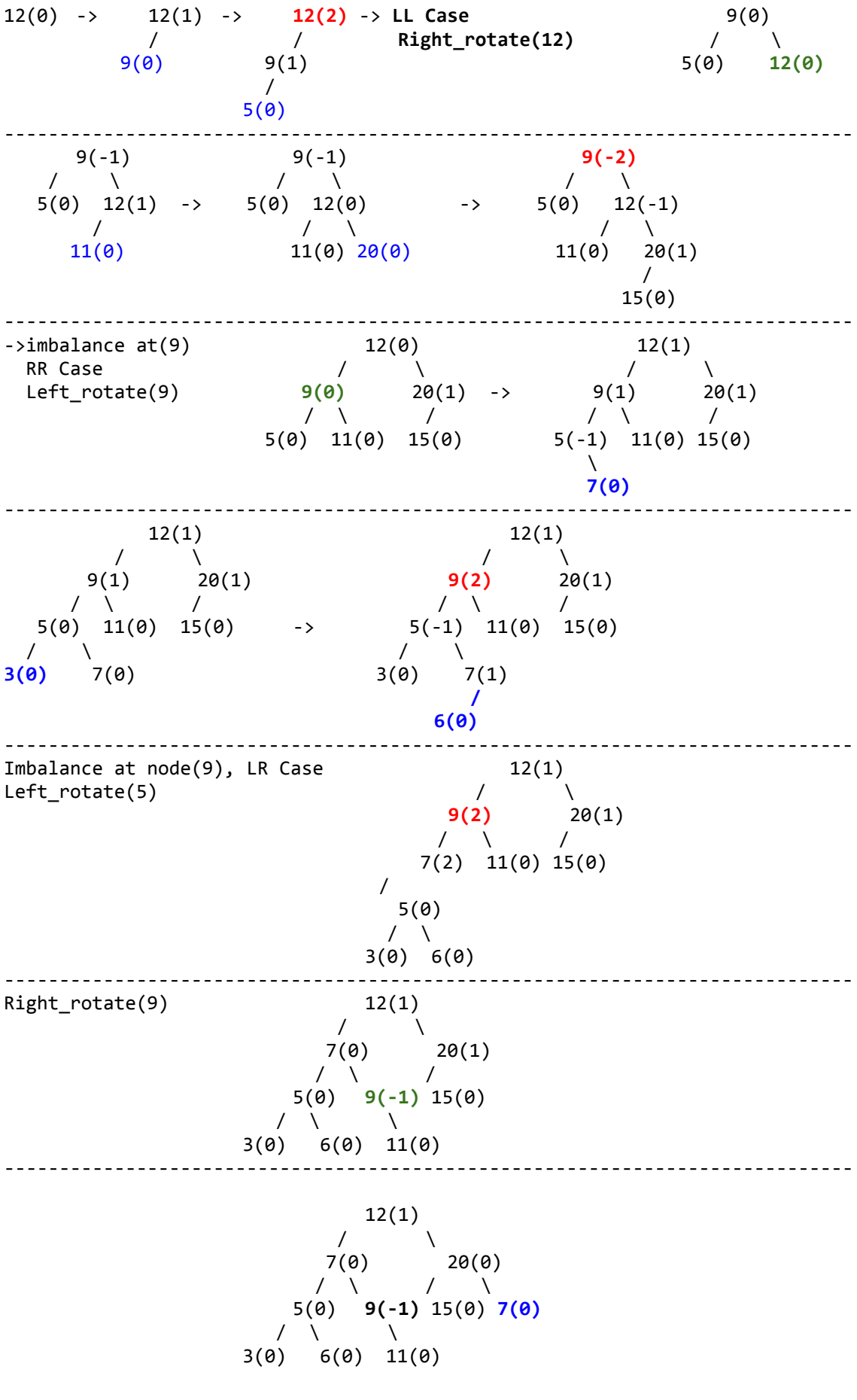
6	3(0) 5(-1) 6(0) 7(1) **9**(2) 11(0) 12(1) 15(0) 20(1) Imbalance at node: 9 LR Case Left_rotate(5), right_rotate(9) 3(0) 5(0) 6(0) 7(0) **9**(-1) 11(0) 12(1) 15(0) 20(1) Root=12
27	3(0) 5(0) 6(0) 7(0) **9**(-1) 11(0) 12(1) 15(0) 277(0) 20(0) Balanced Root=12
-1	Status: 3(0) 5(0) 6(0) 7(0) **9**(-1) 11(0) 12(1) 15(0) 20(0) 27(0)

Note:

- **Do not** use any recursive implementation

The status of the tree is finally supposed to be like this:




12(0) -> 12(1) -> 12(2) -> LL Case
Right_rotate(12)
9(0)
5(0) 12(0)
9(0)
5(0)
9(1)
5(0)
9(-1)
5(0) 12(1) -> 5(0) 12(0) -> 5(0) 12(-1)
11(0) 11(0) 20(0) 11(0) 20(1)
15(0)
9(-2)
->imbalance at(9)
RR Case
Left_rotate(9)
12(0)
9(0) 20(1) -> 9(1) 20(1)
5(0) 11(0) 15(0) 5(-1) 11(0) 15(0)
7(0)
12(1)
9(1) 20(1)
5(0) 11(0) 15(0) -> 5(-1) 11(0) 15(0)
3(0) 7(0) 3(0) 7(1)
6(0)
9(2)
Imbalance at node(9), LR Case
Left_rotate(5)
12(1)
9(2) 20(1)
7(2) 11(0) 15(0)
5(0)
3(0) 6(0)
Right_rotate(9)
12(1)
7(0) 20(1)
5(0) 9(-1) 15(0)
3(0) 6(0) 11(0)
12(1)
7(0) 20(0)
5(0) 9(-1) 15(0) 7(0)
3(0) 6(0) 11(0)

Task 3: Basic operations of Trie data structure

Implement the basic operations of the 'Trie' data structure by implementing the following functions:

- void **Insert**(): Inserts a string in a trie
- boolean **Search**(): Returns if the query string is a valid word.
- void **Display**(): Shows all the words that are stored in the Trie in lexicographically sorted order.

The first line of input contains space-separated words that need to be inserted in the Trie. Once the words are inserted, display all of them.
The following line contains another collection of query words. Print **T/F** based on their presence/absence.

Sample Input	**Sample Output**
toy algo algorithm to tom also algea tommy toyota toy toyo al also algorithm algorithmic	algea algo algorithm also to tom tommy toy toyota T F F T T F

<u>Task 4</u>: Find the number of words starting with a certain prefix

Suppose a set of words is stored in a Dictionary. Given a *prefix*, your task is to find out how many words start with it.

The first input line will contain *N* and *Q*, where *N* represents the number of words in the dictionary, and Q is the number of queries. Print the number of words starting with each corresponding prefix.

Sample Input	**Sample Output**
10 10 Beauty Beast Beautiful Amazing Amsterdam Beautify Banana Xray Beauty Glorifying	
A	2
Am	2
AM	2
Beauty	1
Beaut	3
Beast	1
Ing	0
AMS	1
Be	4
B	5

Note: Convert every string/prefix in lowercase before storing/ searching.

Task 5: Search Suggestions

You are given a set of ‘products’ and a string ‘searchWord’. Design a solution that suggests **at most three** products after each character of searchWord is typed. Suggested products should have a common prefix with searchWord. If there are more than three products with a common prefix, follow the lexicographical order.

Input (products)	**Output**	**Explanation (searchWord)**
mobile mouse moneypot monitor mousepad mouse	mobile moneypot monitor mobile moneypot monitor mouse mousepad mouse mousepad mouse mousepad	**‘m’** **‘mo’** **‘mou’** (only 2 matches) **‘mous’** (only 2 matches) **‘mouse’** (only 2 matches)
havana havana	havana havana havana havana havana	**‘h’** **‘ha’** **‘hav’** **‘hava’** **‘havana’**
juice jeerapani icecream jelly jam jackfruit jalapeno jeans	jackfruit jalapeno jam Jelly jeerapani Null Null Null	**‘J’**: 6 words matched. Printed only the first 3 in lexicographical order. **‘Je’**: 2 matches No match found for **‘jea’**, **‘jean’**, **‘jeans’**. Hence null.