National Yang Ming Chiao Tung University
Department of Electrical and Computer Engineering
Data Structures, Fall 2023

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Programming Assignment #4

Tree

1. Problem Description

The Lightning Bear Kingdom is the greatest country in the world. There are **N** cities in the kingdom. Each city is represented by an integer between **1** and **N**, with city **S** being the capital of the kingdom. The cities are connected by roads, where each road is of unit length and connects two cities. Teacher Lightning Bear, the king of the Lightning Bear Kingdom, is the smartest person in the world. He designs the kingdom to be as simple as possible. In particular, he uses only **N−1** roads to make all cities fully connected with each other. As a consequence, there is one and only one path for any pair of cities.

Now, Teacher Lightning Bear wants to enjoy his vacation at his favorite resort which is in city **R**. Thunder Tigger, a dear friend of Teacher Lightning Bear, wants to find where Teacher Lightning Bear is, in order to surprise him. Thunder Tigger thus asks you, the secretary of Teacher Lightning Bear, to provide some hints. Nevertheless, Teacher Lightning Bear does not really like surprises. If he finds that you leak the resort information to Thunder Tigger, he can get angry and you will certainly be fired. As a consequence, you can only communicate with Thunder Tigger with the following protocol.

- Thunder Tigger proposes city **c** as the query.
- You first write down the path from **c** to the capital city **S** as

$$(a_0 = c) \rightarrow a_1 \rightarrow a_2 \ldots \rightarrow (a_n = S)$$

- You then write down the path from **c** to the resort city **R** as

$$(b_0 = c) \rightarrow b_1 \rightarrow b_2 \ldots \rightarrow (b_m = R)$$

- Now you find the largest $\boldsymbol{i}$ such that $(a_j = b_j)$ for all $(j \leq i)$, and return a_i (or b_i, as $b_i = a_i$) to Thunder Tigger.

Note that it is totally possible that Teacher Lightning Bear is enjoying his vacation in the capital city. That is, **R**=**S**.

Thunder Tigger, who is very eager to know where Teacher Lightning Bear is, starts bouncing across the kingdom and querying you with many different **c**. You thus decide to write a program to help answer the queries faster.

2. Input Format

The first line of input contains four numbers **N**, **Q**, **S**, **R**, separated by space. They indicate the number of cities, the number of queries, the capital city, and the resort city, respectively.

Each of the next **N−1** lines contain two integers **a**, **b** separated by space, which indicates a (bi-directional) road between city **a** and city **b**.

Each of the next **Q** lines contain one integer **c**, indicating the query from Thunder Tigger.

(Use cin to get terminal input)

3. Output Format

For each query, print a line that contains a single integer a_i, which means the answer that should be returned to Thunder Tigger.

(Use cout to output terminal result)

4. Sample Input / Output

Sample Input 1

4 4 1 4
1 2
2 3
3 4
1
2
3
4

Sample Output 1

1
2
3
4

Sample Input 2

5 5 2 4
1 2
1 3
1 4
1 5

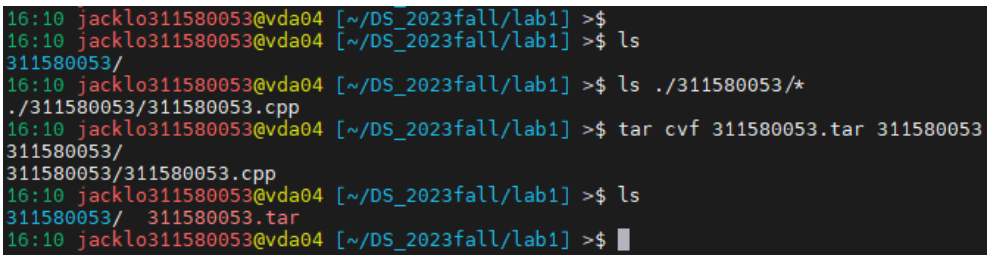
4
2
1
5
3

Sample Output 2

4
2
1
1
1

5. Submission Information

1. Your program must be written in C/C++ language and can be compiled on the Linux platform.
2. Please put the required files in a folder named with your Student_ID and the required files should also be named with your Student_ID (.cpp, .c).
3. To submit your program, please use the command below to compress the folder named with "[Student_ID].tar" in the Linux environment and upload it to E3.
   tar cvf Student_ID.tar Student_ID



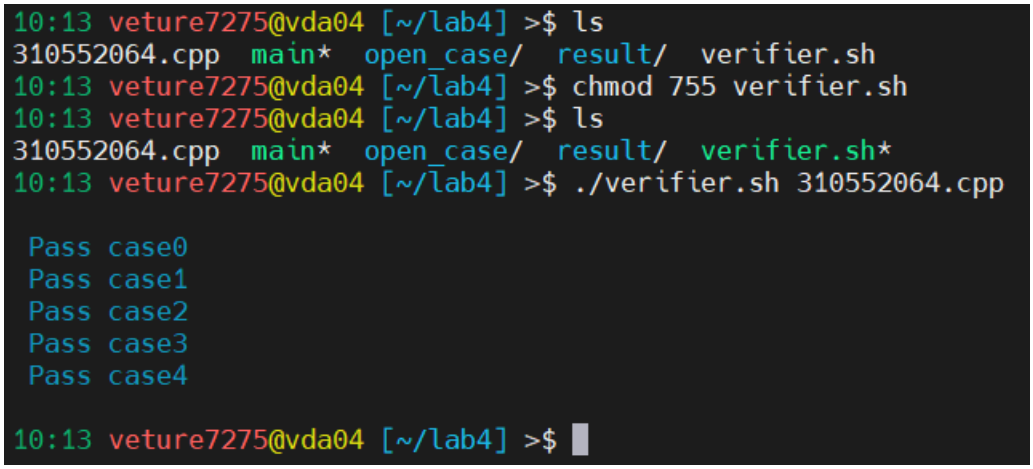
6. Due Date

Be sure to upload the tar file by "December 5, 2023". There will be a 10% penalty per day for the first four days (weekend included) and will not be accepted afterwards.

7. Grading Policy

The programming assignment will be graded based on the following rules:

- Pass the open cases with compilable source code (60%)



- Pass the hidden cases with compilable source code (40%)
- -10% of your total score if any file occurs naming error or not compress
- ***No credits for plagiarism***
- If you don't process input and output from terminal, you will get 0 score

8. Hint

N cities + N-1 roads will become a tree, you can find a path via tree traversal.