

Problem 9: GoatC-Tree

14 Points

Problem ID: goat

Rank: 4

Introduction

G.O.A.T. stands for Greatest common divisor Of All Time, which is a function on a rooted tree. Your friend Bob is offering to pay you like three quintillion dollars if you can help them answer a bunch of GOAT queries for their math homework or whatever

Problem Statement

You are given N vertices (numbered 1 to N) forming a tree rooted at vertex 1. The vertices are labeled with positive integers A_1, A_2, \dots, A_N , where A_i is the label of vertex i . Find the result of each of Q GOAT queries G_1, G_2, \dots, G_Q , where the result of query G_i is $GOAT(G_i)$: the sum of $\gcd(A_u, A_v)$ for all unordered pairs of vertices (u, v) modulo 998244353, such that u and v are present in vertex G_i 's subtree and $u \neq v$.

Formally:

$$GOAT(G_i) = \sum_{\forall u, v \in subtree(G_i), u \neq v} \gcd(A_u, A_v) \pmod{998244353}$$

Input Format

The first line of the input contains an integer T denoting the number of test cases that follow.

For each test case:

- The first line contains two space-separated integers N Q , where:
 - N denotes the size of the tree.
 - Q denotes the number of GOAT queries.
- The second line contains N space-separated integers P_1 P_2 ... P_N , denoting that each vertex i 's parent in the tree is vertex P_i
 - P_1 will always be zero to represent vertex 1 being the root of the tree.
- The third line contains N space-separated integers A_1 A_2 ... A_N
- The fourth line contains Q space-separated integers G_1 G_2 ... G_Q , denoting each GOAT query.

Output Format

For each test case, output Q space-separated integers $GOAT(G_1)$ $GOAT(G_2)$... $GOAT(G_Q)$

Constraints

$1 \leq G_i \leq N$ for all GOAT queries.

Main Test Set

$1 \leq T \leq 100$

$1 \leq N, Q \leq 10^5$

$1 \leq A_i \leq 10^4$ for all i

The sum of N across all test cases in an input file does not exceed 10^5 .

The sum of Q across all test cases in an input file does not exceed 10^5 .

Sample Test Cases

Sample Input

[Download](#)

```
3
5 1
0 1 1 2 2
6 18 15 4 12
1
11 2
0 3 1 8 3 2 8 1 7 4 4
11 28 33 24 25 16 7 12 9 10 12
8 3
14 3
0 1 1 1 1 2 2 2 3 4 6 6 6 8
18 15 6 14 9 28 12 16 24 5 32 2 51 42
6 2 1
```

Sample Output

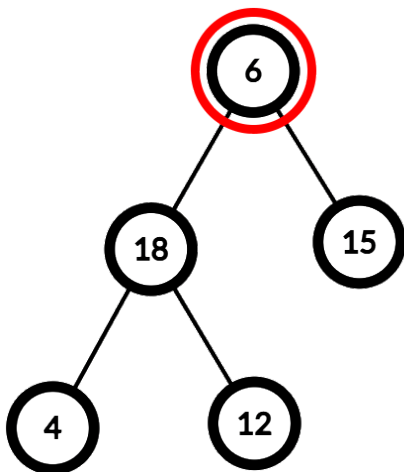
[Download](#)

```
36
57 9
11 93 302
```

Main Sample Explanations

Test Case #1:

The input tree looks like this:



The vertex with GOAT a query performed on it is circled in red.

The vertex pairs (u, v) in vertex 1's subtree are listed below:

- $(1, 2)$: $\gcd(A_1, A_2) = \gcd(6, 18) = 6$
- $(1, 3)$: $\gcd(A_1, A_3) = \gcd(6, 15) = 3$
- $(1, 4)$: $\gcd(A_1, A_4) = \gcd(6, 4) = 2$
- $(1, 5)$: $\gcd(A_1, A_5) = \gcd(6, 12) = 6$
- $(2, 3)$: $\gcd(A_2, A_3) = \gcd(18, 15) = 3$
- $(2, 4)$: $\gcd(A_2, A_4) = \gcd(18, 4) = 2$
- $(2, 5)$: $\gcd(A_2, A_5) = \gcd(18, 12) = 6$
- $(3, 4)$: $\gcd(A_3, A_4) = \gcd(15, 4) = 1$
- $(3, 5)$: $\gcd(A_3, A_5) = \gcd(15, 12) = 3$
- $(4, 5)$: $\gcd(A_4, A_5) = \gcd(4, 12) = 4$

GOAT(1) is the sum of these values modulus 998244353, which equals 36.