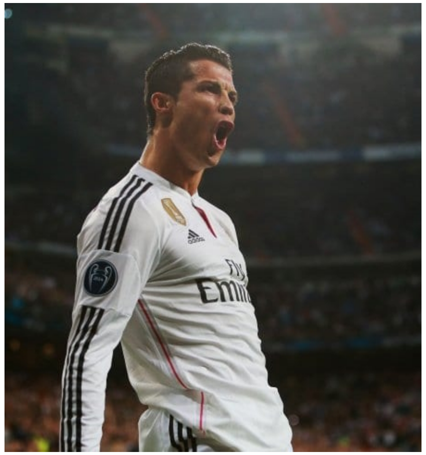
El Bicho

DondeEstasCR7



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Contents

1 Algos

1.1 Fast Io

```cpp
#include <bits/stdc++.h>
#include <ext/pb_ds/assoc_container.hpp>
#include <ext/pb_ds/tree_policy.hpp>

#define cpu() ios::sync_with_stdio(false);cin.tie(nullptr);

using namespace std;
using namespace __gnu_pbds;
template <class T>
using ordered_set = tree<T, null_type, less_equal<T>, rb_tree_tag, tree_order_statistics_node_update>;

#define pb push_back
#define sz(a) ((int)(a).size())
#define ff first
#define ss second
#define all(a) (a).begin(), (a).end()
#define allr(a) (a).rbegin(), (a).rend()
#define approx(a) fixed << setprecision(a)

template <class T> void read(vector<T> &v);
template <class F, class S> void read(pair<F, S> &p);
template <class T, size_t Z> void read(array<T, Z> &a);
template <class T> void read(T &x) {cin >> x;}
template <class R, class... T> void read(R& r, T&... t){read(r); read(t...);};
template <class T> void read(vector<T> &v) {for(auto& x : v) read(x);}
template <class F, class S> void read(pair<F, S> &p) {read(p.ff, p.ss);}
template <class T, size_t Z> void read(array<T, Z> &a) { for(auto &x : a) read(x); }

template <class F, class S> void pr(const pair<F, S> &x);
template <class T> void pr(const T &x) {cout << x;}
template <class R, class... T> void pr(const R& r, const T&... t) {pr(r); pr(t...);}
template <class F, class S> void pr(const pair<F, S> &x) {pr("{", x.ff, ",␣", x.ss, "}\n");}
void ps() {pr("\n");}
template <class T> void ps(const T &x) {pr(x); ps();}
template <class T> void ps(vector<T> &v) {for(auto& x : v) pr(x, '␣'); ps();}
template <class T, size_t Z> void ps(const array<T, Z> &a) { for(auto &x : a) pr(x, '␣'); ps(); }
template <class F, class S> void ps(const pair<F, S> &x) {pr(x.ff, '␣', x.ss); ps();}
template <class R, class... T> void ps(const R& r,  const T &...t) {pr(r, '␣'); ps(t...);}

using ll = long long;
const double PI = 3.141592653589793;
const ll MX = 1e9 + 1;

void solve() {

}

int main() {
  cpu();

  int t = 1;
  //cin >> t;
  while (t--) {
    solve();
  }

  return 0;
}
```

2 Bit Manipulation

Técnicas para manipular bits individuales y operaciones a nivel de bit. Incluye macros útiles para competencias de programación.

2.1 Bits

Macros esenciales para manipulación de bits: verificar potencias de 2, establecer/limpiar bits, contar bits, y operaciones con LSB/MSB.

```cpp
using ull = unsigned long long;
const ull UNSIGNED_LL_MAX = 18'446'744'073'709'551'615;
// Verifica si S es potencia de dos (y distinto de cero)
#define isPowerOfTwo(S) ((S) && !((S) & ((S) - 1)))
// Retorna la potencia de dos mas cercana a S
```

```
#define nearestPowerOfTwo(S) (1LL << lround(log2(S)))
// Calcula S % N cuando N es potencia de dos
#define modulo(S, N) ((S) & ((N) - 1))

// Verifica si el bit esta encendido (bit en 1)
#define isOn(S, i) ((S) & (1LL<<(i)))
// Enciende el bit (Lo pone en 1)
#define setBit(S, i) ((S) |= (1LL<<(i)))
// Apaga el bit (Lo pone en 0)
#define clearBit(S, i) ((S) &= ~(1LL<<(i)))
// Invierte el estado del bit (0 <-> 1)
#define toggleBit(S, i) ((S) ^= (1LL<<(i)))
// Enciende los primeros 'n' bits (idx-0)
#define setAll(S, n) ((S) = ((n)>=64 ? ~0LL : (1LL << (n))-1))

// Extrae el bit menos significativo 0100 (Least Significant Bit)
#define lsb(S) ((S) & -(S))
// Numero de ceros a la derecha (Posicion del LSB, idx-0)
#define idxLastBit(x) __builtin_ctzll(x)
// Extrae el bit mas significativo 0100 (Most Significant Bit)
#define msb(S) (1LL << (63 - __builtin_clzll(S)))
// Posicion del MSB (63 - ceros a la izquierda, idx-0)
#define idxFirstBit(x) (63 - __builtin_clzll(x))

#define countAllOnes(x) __builtin_popcountll(x)
// Apaga el ultimo bit encendido (el menos significativo)
#define turnOffLastBit(S) ((S) & ((S) - 1))
// Enciende el ultimo cero menos significativo
#define turnOnLastZero(S) ((S) | ((S) + 1))
// Apaga todos los bits encendidos mas a la derecha consecutivos
#define turnOffLastConsecutiveBits(S) ((S) & ((S) + 1))
// Enciende los ceros consecutivos mas a la derecha
#define turnOnLastConsecutiveZeroes(S) ((S) | ((S) - 1))

// Mascara de bits (mask -> subconjunto) O(2^N)
for (int mask = 0; mask < (1 << N); mask++)

// Recorrer subconjuntos de un superconjunto (menos el vacio)
int b = 0b1011; // Representacion binaria de un decimal en int
for (int i = b; i; i = (i - 1) & b) {
  cout << bitset<4>(i) << "\n";
}

void printBin(ll x) {
  // 63 -> unsigned ll, 62 -> ll, 31 -> unsigned int, 30 -> int
  for (ll i = 63; i >= 0; i--)
    cout << ((x >> i) & 1);
  cout << '\n';
}
```

3 Combinatory

3.1 Combi Brute Sin Mod

```
// nCk brute force sin MOD n <= 20
long long nCk_bruteforce(long long n, long long k) {
    if (k < 0 || k > n) return 0;
    long long res = 1;
    for (long long i = 1; i <= k; i++) {
        res = res * (n - i + 1) / i; // aqui la division es exacta
    }
    return res;
}

// nPk brute force sin MOD n <= 20
long long nPk_bruteforce(long long n, long long k) {
    if (k < 0 || k > n) return 0;
    long long res = 1;
    for (long long i = 0; i < k; i++) {
        res *= (n - i);
    }
    return res;
}
```

3.2 Combinatory

OJO: Es necesario usar binpow con MOD primo

```
// Devuelve el inverso modular de a mod MOD
// Usa el Teorema Pequeno de Fermat: a^(MOD-2) === a^(-1) (mod MOD)
// (valido solo si MOD es primo)
ll inv(ll a, ll p = MOD) {
    return binpow(a, p - 2, p);
}

// Factoriales e inversos factoriales precomputados
// fact[n]  = n! mod MOD
// invf[n]  = (n!)^(-1) mod MOD
// Precomputa en O(n)
vector<ll> fact(MAXN + 1), invf(MAXN + 1);

void precompute_factorials() {
    fact[0] = 1;
    for (int i = 1; i <= MAXN; i++) {
        fact[i] = fact[i - 1] * i % MOD;
    }
    invf[MAXN] = inv(fact[MAXN]);
    for (int i = MAXN; i > 0; i--) {
        invf[i - 1] = invf[i] * i % MOD;
    }
}

// Combinatoria de n en k: nCk(n, k) para n <= 10^6
// "n choose k" = n! / (k! * (n-k)!) mod MOD
// Retorna 0 si k > n
ll nCk(ll n, ll k) {
    if (k < 0 || k > n) return 0;
    return fact[n] * invf[k] % MOD * invf[n - k] % MOD;
}

// Permutacion de n en k: nPk(n, k) para n <= 10^6
// Calcula permutaciones: "n permute k" = n! / (n-k)! mod MOD
// Retorna 0 si k > n
ll nPk(ll n, ll k) {
    if (k < 0 || k > n) return 0;
    return fact[n] * invf[n - k] % MOD;
}
```

4 Graph

Algoritmos de grafos: DFS, BFS, componentes fuertemente conexas, y otras estructuras de datos para problemas de grafos.

4.1 Bfs

```
vector<bool> vis(n+1);
queue<int> q;
function<void(int)> bfs = [&](int start) {
  vis[start] = true;
  q.push(start);
  while (!q.empty()) {
    int sz = q.size();
    while (sz--) {
      int u = q.front();
      q.pop();
      for (int& v : adj[u]) {
        if (vis[v]) continue;
        vis[v] = true;
        q.push(v);
      }
    }
  }
};

for (int u = 1; u <= n; u++) {
  if (vis[u]) continue;
  bfs(u);
}
```

4.2 Bipartite

```
int N, M; cin >> N >> M;
vector<vector<int>> adj(N + 1);
while (M--) {
  int u, v; cin >> u >> v;
  adj[u].push_back(v);
  adj[v].push_back(u);
}

vector<bool> vis(N + 1);
vector<int> col(N + 1, 0);
// bipartite graph
function<bool(int, int)> dfs = [&](int u, int c) {
  vis[u] = 1;
  col[u] = c;

  for (auto v : adj[u]) {
    if (vis[v] && col[u] == col[v]) return false;
    else if (!vis[v] && !dfs(v, c ^ 1)) return false;
  }
```

```cpp
  return true;
};

for (int i = 1; i <= N; i++) {
  if (vis[i]) continue;
  if (dfs(i, 1) == false) {
    cout << "IMPOSSIBLE";
    return;
  }
}

for (int i = 1; i <= N; i++) cout << (col[i] ? 1 : 2) << '␣';
```

4.3 Dfs

```cpp
vector<bool> vis(n+1);
function<void(int)> dfs = [&](int u) {
  vis[u] = true;
  for (int& v : adj[u]) {
    if (vis[v]) continue;
    dfs(v);
  }
};

for (int u = 1; u <= n; u++) {
  if (vis[u]) continue;
  dfs(u);
}
```

4.4 Dfs 2D

```cpp
int N, M; cin >> N >> M;
vector<vector<char>> grid(N, vector<char>(M));
for (int i = 0; i < N; i++) {
  for (int j = 0; j < M; j++) {
    cin >> grid[i][j];
  }
}

vector<vector<bool>> vis(N, vector<bool>(M));
vector<int> dx = {-1, 1, 0, 0}, dy = {0, 0, -1, 1};
function<void(int, int)> dfs = [&](int x, int y) {
  vis[x][y] = 1;

  for (int d = 0; d < 4; d++) {
    int nx = x + dx[d], ny = y + dy[d];
    if (0 <= nx && nx < N && 0 <= ny && ny < M && grid[nx][ny] == '.' && !vis[nx][ny]) dfs(nx, ny);
  }
};

int comp = 0;
for (int i = 0; i < N; i++) {
  for (int j = 0; j < M; j++) {
    if (vis[i][j] || grid[i][j] == '#') continue;
    dfs(i, j);
    comp++;
  }
}

cout << comp;
```

4.5 Disjoint Set Union Dsu

```cpp
struct DSU{
  vector<int> p, size;
  DSU(int n){
    p.resize(n + 1), size.resize(n + 1,1);
    for(int i = 1; i <= n; i++) p[i] = i;
  }

  int find(int x){
    if(p[x] != x) p[x] = find(p[x]);
    return p[x];
  }

  void merge(int x, int y){
    x = find(x), y = find(y);
    if(x == y) return;
    if(size[x] < size[y]) swap(x, y);
    size[x] += size[y];
    p[y] = x;
  }
};
```

4.6 Djisktra

```cpp
template <class T> using pq = priority_queue<T>;
template <class T> using pqg = priority_queue<T, vector<T>, greater<T>>;

void solve() {
  int n, m; cin >> n >> m;
  vector<vector<pair<int, ll>>> adj(n+1);
  while (m--) {
    int u, v; ll w; cin >> u >> v >> w;
    adj[u].push_back({v, w});
  }

  vector<ll> dist(n+1, MX);
  pqg<pair<ll, int>> q;
  q.push({0LL, 1});
  dist[1] = 0LL;
  while (!q.empty()) {
    auto [d, u] = q.top();
    q.pop();
    if (dist[u] < d) continue;
    for (auto [v, w] : adj[u]) {
      ll new_d = d + w;
      if (new_d < dist[v]) {
        dist[v] = new_d;
        q.push({dist[v], v});
      }
    }
  }

  for (int u = 1; u <= n; u++) cout << dist[u] << ’␣’;
  cout << ’\n’;
}
```

4.7 Lowest Common Ancestor Lca

```
struct LCA{
  int n, l, timer = 0;
  vector<vector<int>> up, adj;
  vector<int> depth, in, out;

  LCA(int _n) {
    n = _n + 1;
    l = ceil(log2(n));
    up.resize(n, vector<int>(l + 1));
    adj.resize(n);
    depth.resize(n);
    in.resize(n);
    out.resize(n);
  }

  void add_edge(int p, int u){
    adj[p].push_back(u);
    adj[u].push_back(p);
  }

  void dfs(int u = 1, int p = 1){
    up[u][0] = p;
    depth[u] = depth[p] + 1;
    in[u] = ++timer;
    for(int level = 1; level <= l; level++){
      up[u][level] = up[up[u][level - 1]][level - 1];
    }
    for(int v : adj[u]){
      if(v == p) continue;
      dfs(v, u);
    }
    out[u] = ++timer;
  }

  bool is_ancestor(int p, int u){
    return in[p] <= in[u] && out[p] >= out[u];
  }

  int query(int u, int v){
    if(is_ancestor(u, v)) return u;
    if(is_ancestor(v, u)) return v;

    for(int bit = l; bit >= 0; bit--){
      if(is_ancestor(up[u][bit], v)) continue;
      u = up[u][bit];
    }
    return up[u][0];
  }

  int ancestor(int u, int k){
    if(depth[u] <= k) return -1;
    for(int bit = 0; bit <= l; bit++){
      if(k >> bit & 1) u = up[u][bit];
    }
    return u;
  }

  int distance(int u, int v){
    return depth[u] + depth[v] - 2 * depth[query(u, v)];
  }
};
```

4.8 Scc

Algoritmo de Tarjan para encontrar componentes fuertemente conexas (SCC) en un grafo dirigido.

```
// "These works to find a componente fuertemente conexa that it's in directed graph"
struct SCC{
  int N = 0, id;
  vector<vector<int>> adj;
  vector<int> ind, low;
  stack<int> s;
  vector<bool> in_stack;
  vector<vector<int>> components;
  vector<int> component_id;

  //1-indexed
  SCC(int n = 0){ N = n + 1, adj.assign(N, {}); }
  SCC(const vector<vector<int>> & _adj){ adj = _adj, N = adj.size(); }

  void add_edge(int from, int to){
    adj[from].push_back(to);
  }

  void dfs(int u){
    low[u] = ind[u] = id++;
    s.push(u);
    in_stack[u] = true;
    for(int v : adj[u]){
      if(ind[v] == -1){
        dfs(v);
        low[u] = min(low[u], low[v]);
      }else if(in_stack[v]){
        low[u] = min(low[u], ind[v]);
      }
    }
    if(low[u] == ind[u]){
      components.emplace_back();
      vector<int> & comp = components.back();
      while(true){
        assert(!s.empty());
        int x = s.top(); s.pop();
        in_stack[x] = false;
        component_id[x] = components.size() - 1;
        comp.push_back(x);
        if(x == u) break;
      }
    }
  }

  vector<vector<int>> get(){
    ind.assign(N, - 1); low.assign(N, -1); component_id.assign(N, -1);
    s = stack<int>();
    in_stack.assign(N, false);
    id = 0;
    components = {};
    for(int i = 1; i < N; i++)
      if(ind[i] == -1) dfs(i);

    // reverse(components.begin(), components.end()); return components; // SCC in topological order
    return components; // SCC in reverse topological order
  }
};
```

4.9 Topological Sort

```
vector<int> top_sort(vector<vector<int>>& adj){
  int n = adj.size();
  bool cycle = false;
  vector<int> sorted, color(n);
  function<void(int)> dfs = [&](int u){
    color[u] = 1;
    for(int v : adj[u]){
      if(color[v] == 0 && !cycle) dfs(v);
      else if(color[v] == 1) cycle = true;
    }
    color[u] = 2;
    sorted.push_back(u);
  };
  for(int i = 1; i < n; i++){
    if(color[i] == 0 && !cycle) dfs(i);
  }
  if(cycle){return {};}
  reverse(sorted.begin(), sorted.end());
  return sorted;
}
```

5 Number Theory

Primeros 180 Primos: 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97, 101, 103, 107, 109, 113, 127, 131, 137, 139, 149, 151, 157, 163, 167, 173, 179, 181, 191, 193, 197, 199, 211, 223, 227, 229, 233, 239, 241, 251, 257, 263, 269, 271, 277, 281, 283, 293, 307, 311, 313, 317, 331, 337, 347, 349, 353, 359, 367, 373, 379, 383, 389, 397, 401, 409, 419, 421, 431, 433, 439, 443, 449, 457, 461, 463, 467, 479, 487, 491, 499, 503, 509, 521, 523, 541, 547, 557, 563, 569, 571, 577, 587, 593, 599, 601, 607, 613, 617, 619, 631, 641, 643, 647, 653, 659, 661, 673, 677, 683, 691, 701, 709, 719, 727, 733, 739, 743, 751, 757, 761, 769, 773, 787, 797, 809, 811, 821, 823, 827, 829, 839, 853, 857, 859, 863, 877, 881, 883, 887, 907, 911, 919, 929, 937, 941, 947, 953, 967, 971, 977, 983, 991, 997, 1009, 1013, 1019, 1021, 1031, 1033, 1039, 1049, 1051, 1061, 1063, 1069.

5.1 Euler Toliente

```
class EulerTotiente {
  public:
  //* metodo en O(sqrt(n))
  template <typename T>
  T euler_classic(T n) {
    T result = n;
    for(T i = 2; i * i <= n; i++) {
      if(n % i == 0) {
        while(n % i == 0) n /= i;
        result -= result / i;
      }
    }
    if(n > 1) {
      result -= result / n;
    }
    return result;
  }

  //* metodo en O(nlog(log(n))
  void euler_faster(int n) {
    vector<int> phi(n + 1);
    for(int i = 0; i <= n; i++) {
      phi[i] = i;
    }
    for(int i = 2; i <= n; i++) {
      if(phi[i] == i) {
        for(int j = i; j <= n; j += i) {
          phi[j] -= phi[j] / i;
        }
      }
    }
    for(int i = 1; i <= n; i++) {
      cout << i << '␣' << phi[i] << '\n';
    }
  }
};
```

5.2 Gcd Lcm

```
// Maximo comun divisor (GCD): Algoritmo de Euclides
int gcd(int a, int b) {
    if (a > b) swap(a, b);
    if (a == 0) return b;
    return gcd(b % a, a);
}

// Minimo comun multiplo (LCM): Calculado con GCD
    int lcm(int a, int b) {
    return (a * b) / gcd(a, b);
}
```

5.3 Number Theory

```
// Divisores de N: Hasta N = 10^6
vector<int> divisores(int N) {
  vector<int> divs;
  for (int d = 1; d * d <= N; d++) {
    if (N % d == 0) {
      divs.push_back(d);
      if (N / d != d) divs.push_back(N / d);
    }
  }
  return divs;
}

// Factorizacion de N: Hasta N = 10^6
vector<pair<int, int>> factorizar(int N) {
  vector<pair<int, int>> facts;
  for (int p = 2; p * p <= N; p++) {
    if (N % p == 0) {
      int exp = 0;
      while (N % p == 0) {
        exp++;
        N /= p;
      }
      facts.push_back({ p, exp });
    }
  }
  if (N > 1) facts.push_back({ N, 1 });
  return facts;
}

// Primalidad: Hasta N = 10^6 - O(sqrt(N))
bool isPrime(int N) {
  if (N < 2) return false;
  for (int d = 2; d * d <= N; d++) {
    if (N % d == 0) return false;
  }
  return true;
}
```

5.4 Phi Euler

Phi(n) = contar la cantidad de numero coprimos entre 1 a n

```
int phi(int n) {
    int ans = n;
    for(int i = 2; i * i <= n; i++) {
        if(n % i == 0) {
            while (n % i == 0) {
                n /= i;
            }
            ans -= ans / i;
        }
    }
    if(n > 1) {
        ans -= ans / n;
    }
    return ans;
}

//* phi(n) -> complex: O(log(log(n)))
void phi_1_to_n(int n) {
    vector<int> phi(n + 1);
    for (int i = 0; i <= n; i++)
        phi[i] = i;

    for (int i = 2; i <= n; i++) {
        if (phi[i] == i) {
            for (int j = i; j <= n; j += i)
                phi[j] -= phi[j] / i;
        }
    }
}
```

5.5 Potenciacion Binaria

```
using ll = long long;
const int MAXN = 1e6;   // limite superior de n
const ll MOD = 1e9 + 7; // primo grande

// Potenciacion binaria modular a^b mod p
ll binpow(ll a, ll b, ll m = MOD) {
    a %= m;
    ll res = 1;
    while (b > 0) {
        if (b & 1)
            res = res * a % m;
        a = a * a % m;
        b >>= 1;
    }
    return res;
}
```

5.6 Sieve

```
// Criba de Eratostenes: Hasta N = 10^6
void sieve(vector<bool>& is_prime) {
  int N = (int) is_prime.size();
  if (!is_prime[0]) is_prime.assign(N+1, true);
  is_prime[0] = is_prime[1] = false;
  for (int p = 2; p * p <= N; p++) {
    if (is_prime[p]) {
      for (int i = p * p; i <= N; i += p) {
        is_prime[i] = false;
      }
    }
  }
}
```

5.7 Sieve Bitset

```
// Hasta N = 10^8 aprox en 1s
const int MAX_V = 1e7 + 5;
bitset<MAX_V> composite;
void sieve() {
    composite[0] = composite[1] = true;
    for (int i = 2; i * i < MAX_V; i++) {
        if (composite[i]) continue;
        for (int j = i * i; j < MAX_V; j += i) {
            composite[j] = true;
        }
    }
}

int main() {
    sieve();
    for (int i = 2; i < 100; i++) {
        cout << i << "␣is_primes␣:␣" << !composite[i] << '\n';
    }
}
```

5.8 Sum Of Divisors

```
//* Sum of divs
long long SumOfDivisors(long long num) {
    long long total = 1;

    for (int i = 2; (long long)i * i <= num; i++) {
        if (num % i == 0) {
            int e = 0;
            do {
                e++;
                num /= i;
            } while (num % i == 0);

            long long sum = 0, pow = 1;
            do {
                sum += pow;
                pow *= i;
            } while (e-- > 0);
            total *= sum;
        }
    }
    if (num > 1) {
        total *= (1 + num);
    }
    return total;
}
```

6 Segment Tree

6.1 Find Two Numbers

```
// "find two number where the sum is x, and gcd(a, b) > 1" b
auto find = [&](ll x){
  for(int d = 2; d <= x / 2; d++){
    if(x % d == 0){
      ll m = 1, n = (x / d) - 1;
      ll a = d * m, b = d * n;
      if(__gcd(a, b) > 1){
        cout<< a << '␣' << b;
        ps();
        return;
      }
    }
  }
};
```

6.2 Segment Tree Recursivo

```
template<typename T>
struct segment_tree{
```

```cpp
  int N;
  T Z = 0;
  vector<T> tree;
  segment_tree(int N) : N(N) {
    tree.resize(2 * N);
  }

  segment_tree(vector<T>& A){
    N = (int) A.size();
    tree.resize(2 * N);
    build(A, 1, 0, N - 1);
  }

  auto& operator[](size_t i) { return tree[i]; } // this funciton works for get element int this position
private:

  T op(T& a, T& b){ return a + b; }
  // O (n)
  void build(vector<T>& values, int node, int l, int r){
    // if l and r are equal both are leaf node
    // left node = [l, m]
    // m = (l + r) / 2
    // left and right are nodes
    // left interval = [l, m], right intervla = [m + 1, r]
    // after complete fill nodes of left and right, we need to fill the [l, r] node
    if(l == r){
      tree[node] = values[l];
      return;
    }
    int m = (l + r) >> 1;
    int left = node + 1;
    int right = node + 2 * (m - l + 1);

    build(values, left, l, m);
    build(values, right, m + 1, r);

    tree[node] = op(tree[left], tree[right]);
  }

  // O (log N)
  void modify(int pos, T value, int node,  int l,  int r){
    // if l and r are equal, we found our node and update it
    if(l == r){
      tree[node] = value;
      return;
    }
    int m = (l + r) >> 1; // we get the mid
    int left = node + 1;
    int right = node + 2 * (m - l + 1);

    if(pos <= m) modify(pos, value, left, l, m);
    else modify(pos, value, right, m + 1, r);

    tree[node] = op(tree[left], tree[right]);
  }

  void update(int pos, T value, int node,  int l,  int r){
    // if l and r are equal, we found our node and update it
    if(l == r){
      tree[node] = op(tree[node], value);
      return;
    }
    int m = (l + r) >> 1; // we get the mid
    int left = node + 1;
    int right = node + 2 * (m - l + 1);

    if(pos <= m) update(pos, value, left, l, m);
    else update(pos, value, right, m + 1, r);

    tree[node] = op(tree[left], tree[right]);
  }

  // O(log N)
  T query(int ql, int qr, int node, int l, int r){
    if(r < ql || l > qr) return Z; // CHECK
    if(ql <= l && r <= qr) return tree[node];
    int m = (l + r) >> 1;
    int left = node + 1;
    int right = node + 2 * (m - l + 1);
    T ansL = query(ql, qr, left, l, m);
    T ansR = query(ql, qr, right, m + 1, r);
    return op(ansL, ansR);
  }
public:
    void build(vector<T>& values){ build(values, 1, 0, N - 1); }

    void modify(int pos, T value){ modify(pos, value, 1, 0, N - 1); }

    void update(int pos, T value){ update(pos, value, 1, 0, N - 1); }

    T query(int ql, int qr){ return query(ql, qr, 1, 0, N - 1); }
  };
```

6.3 Segment Tree V2

```
// "This segment_tree I understand better how it works"
template<typename T>
struct seg_tree {
    int N;
    T Z = 0;
    vector<T> tree;

    seg_tree(int N) : N(N) {
        tree.resize(4 * N);
    }

    seg_tree(vector<T>& A) {
        N = (int)A.size();
        tree.resize(4 * N);
        build(A, 1, 0, N-1);
    }

private:
    T op(T a, T b) {
        return a + b;
    }

    void build(vector<T>& a, int node, int left, int right) {
        if(left == right) {
            tree[node] = a[left];
            return;
        }
        int mid = (left + right) >> 1;
        build(a, 2 * node, left, mid);
        build(a, 2 * node + 1, mid + 1, right);
        tree[node] = op(tree[2 * node], tree[2 * node + 1]);
    }

    void modify(int pos, T value, int node, int left, int right) {
        if(left == right) {
            tree[node] = value;
            return;
        }
        int mid = (left + right) >> 1;
        if(pos <= mid)
            modify(pos, value, 2 * node, left, mid);
        else
            modify(pos, value, 2 * node + 1, mid + 1, right);
        tree[node] = op(tree[2 * node], tree[2 * node + 1]);
    }

    T query(int l, int r, int node, int left, int right) {
        if(r < left || l > right) return Z;
        if(l <= left && right <= r) return tree[node];
        int mid = (left + right) >> 1;
        T leftSum = query(l, r, 2 * node, left, mid);
        T rightSum = query(l, r, 2 * node + 1, mid + 1, right);
        return op(leftSum, rightSum);
    }

public:
    void build(vector<T>& a) { build(a, 1, 0, N-1); }
    void modify(int pos, T value) { modify(pos, value, 1, 0, N-1); }
    T query(int l, int r) { return query(l, r, 1, 0, N-1); }
};
```

6.4 Segment Tree V3

```
// snippet seg_tree_2 "Description" b
template<class T>
struct segment_tree{
    int n;
    vector<T> tree;

    segment_tree(int n){
        this -> n = n;
        tree.resize(2 * n);
    }

    segment_tree(vector<T>& values){
        this -> n = values.size();
        tree.resize(2 * n);
        for(int i = 0; i < n; i++) upd(i, values[i]);
    }

    //CHANGE
    T compare(T a, T b){
        return a + b;
    }

    void modify(int index, T value){
        index += n;
        tree[index] = value;
        for(index >>= 1; index >= 1; index >>= 1) tree[index]= compare(tree[2 * index], tree[2 * index + 1]);
    }

    void upd(int index, T value){
        index += n;
        tree[index] = compare(tree[index], value);
        for(index >>= 1; index >= 1; index >>= 1) tree[index]= compare(tree[2 * index], tree[2 * index + 1]);
    }

    //BOTTOM - TOP
    T query(int first, int last){
        first += n, last += n;
        T ans = 0;
        while(first <= last){
            if(first % 2 == 1) ans = compare(ans, tree[first++]);
            if(last % 2 == 0) ans = compare(ans, tree[last--]);
            first >>= 1, last >>= 1;
        }
        return ans;
    }
 }
};
```