

# Codebook

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## 1 Templates and Scripts

### 1.1 template.cpp

```
#include <bits/stdc++.h>
using namespace std;
```

// Template

```
// =====
// pbds
// #include <ext/pb_ds/assoc_container.hpp>
// #include <ext/pb_ds/tree_policy.hpp>
// using namespace __gnu_pbds;
// template<typename T, typename comp = less<T>>
// using ordered_set = tree<T, null_type, comp,
// rb_tree_tag, tree_order_statistics_node_update>;

// Debugging
#ifdef LOCAL
#include "debug.h"
#else
#define debug(...)
#define see(x)
#endif

typedef long long ll;
typedef vector<int> VI;
typedef vector<long long> VLL;
typedef vector<bool> VB;
typedef vector<vector<int>> VVI;
typedef pair<int, int> PI;
typedef pair<ll, ll> PLL;
typedef vector<pair<int, int>> VPI;

#define pb push_back
#define ff first
#define ss second
#define mp make_pair
#define all(a) a.begin(), a.end()
#define revall(a) a.rbegin(), a.rend()

#define loop(i, s, e) for (int i = s; i < e; ++i)
#define inp(v) for (auto& x : v) cin >> x
#define outp(v) for (int i = 0, n = v.size(); i < n; ++i) cout << v[i] << " \n"[i == n - 1]

#define nl "\n"
#define yep cout << "YES\n"
#define nope cout << "NO\n"

#define INF (int) 1e9
#define INFL (ll) 1e18
// #define MOD 998244353
#define MOD 1000000007
#define MAXN 300002

// =====
```

```
void solve()
{
}

int main()
{
    ios_base::sync_with_stdio(false);
    cin.tie(NULL);

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

    #ifdef LOCAL
    cerr << "Execution time: " << 1000.f * clock() /
    CLOCKS_PER_SEC << " ms." << nl;
    #endif

    return 0;
}
```

### 1.2 debug.h

```
#include <iostream>
using namespace std;

#define see(x) cerr << #x << ": " << x << nl

template<typename... Args>
void debug(Args... args)
{
    ((cerr << " " << args), ...) << "\n";
}
```

### 1.3 sublime.build

```
{
    "shell_cmd": "g++ -Wall -std=c++20 -O2 -DLOCAL
    $file -o $file_base_name && ./file_base_name <
    input.in> output.out 2> error.log",
    "file_regex": "^(..[:])*:([0-9]+):?([0-9]+)??:?
    (.*)$",
    "working_dir": "${file_path}",
    "selector": "source.c++, source.c, source.cpp",

    "variants":
    [
```

```
{
  "name": "sanitize",
  "shell_cmd": "g++ -Wall -std=c++20 -
fsanitize=address -fsanitize=undefined -DLOCAL
$file -o $file_base_name && ./ $file_base_name <
input.in> output.out 2> error.log"
}
]
```

## 1.4 tasks.json (vs code)

```
{
  "version": "2.0.0",
  "tasks": [
    {
      "label": "cp",
      "type": "shell",
      "command": "",
      "args": [
        "g++",
        "-Wall",
        "-std=c++20",
        "-O2",
        "-DLOCAL",
        "\\${file}\\",
        "-o",
        "\\${fileDirname}/${fileBaseNameNoExtension}\\",
        "&&",
        "\\${fileDirname}/${fileBaseNameNoExtension}\\",
        "<",
        "input.in",
        ">",
        "output.out",
        "2>",
        "error.log"
      ],
      "group": "build",
      "presentation": {
        "reveal": "silent"
      },
      "problemMatcher": {
        "owner": "cpp",
        "fileLocation": ["relative", "${workspaceRoot}"],
        "pattern": {
```

```
      "regex": "^(.*):(\\d+):(\\d+):\\s+(
warning|error):\\s+(.*)$",
      "file": 1,
      "line": 2,
      "column": 3,
      "severity": 4,
      "message": 5
    }
  ]
}
```

## 1.5 Interactive

```
socat EXEC:"./interactor" EXEC:"./soln"
```

# 2 Number Theory

## 2.1 Mod Template

```
ll mod(ll n)
{
  n %= MOD;
  return n < 0 ? MOD + n : n;
}

ll modpow(ll n, ll k)
{
  ll ret = 1;

  while (k)
  {
    if (k & 1) ret = (ret * n) % MOD;
    n = (n * n) % MOD;
    k >>= 1;
  }

  return ret;
}

inline ll inv(ll n)
{
  return modpow(n, MOD - 2);
}

inline ll mul(ll x, ll y)
```

```
{
  return ((x % MOD) * (y % MOD)) % MOD;
}

inline ll dvd(ll x, ll y)
{
  return mul(x, inv(y));
}
```

## 2.2 Binomial Coefficient

```
ll fact[MAXN];

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

ll C(int n, int k)
{
  if (k > n) return 0;
  return (1LL * fact[n] *
    inv((1LL * fact[k] * fact[n - k]) % MOD)) %
    MOD;
}
```

## 2.3 Sieve

```
VI primes;
bool isprime[MAXN];

void sieve()
{
  isprime[1] = false;
  for (int i = 2; i < MAXN; ++i) isprime[i] = true;

  for (int i = 2; i < MAXN; ++i)
  {
    if (!isprime[i]) continue;
    primes.pb(i);

    if (1LL * i * i >= MAXN) continue;
    for (int j = i * i; j < MAXN; j += i)
```

```

        isprime[j] = false;
    }
}

```

## 3 Data Structure

### 3.1 Fenwick Tree

```

struct fenwick
{
    int n;
    vector<ll> tree;

    fenwick(int s)
    {
        n = s;
        tree.assign(n + 1, 0);
    }

    ll get(int i)
    {
        ll res = 0;
        for(; i > 0; i -= i & -i) res += tree[i];
        return res;
    }

    void add(int i, int x)
    {
        for (; i <= n; i += i & -i) tree[i] += x;
    }

    ll rsq(int l, int r)
    {
        return get(r) - get(l - 1);
    }
};

```

### 3.2 Segment Tree

```

template<typename T>
struct segtree
{
    #define left(u) 2 * u + 1
    #define right(u) 2 * u + 2

    int n;

```

```

    T init_val;
    vector<T> tree;
    function<T (T, T)> f;

    bool is_lazy = false;
    T init_lazy;
    vector<T> lazy;
    function<void (T&, T, int, int)> apply_lazy;
    function<void (T&, T)> merge_lazy;

    segtree() {} // Dummy constructor for global
    declaration

    segtree(int sz, function<T (T, T)> f, T val = 0)
    {
        n = sz;
        this->f = f;
        init_val = val;

        tree.assign(1 << (__lg(n - 1) + 2), init_val)
    ;
    }

    // apply(tree[u], lazy[u], l, r)
    // merge(lazy[left(u)], lazy[u])
    void make_lazy(function<void (T&, T, int, int)>
    apply, function<void (T&, T)> merge, T init = 0)
    {
        is_lazy = true;
        init_lazy = init;
        apply_lazy = apply;
        merge_lazy = merge;

        lazy.assign(tree.size(), init_lazy);
    }

    void build(vector<T>& a) { _build(0, 0, n - 1, a)
    ; }
    void update(int i, T x) { _update(0, 0, n - 1, i,
    x); }
    void update(int l, int r, T x) { _update_range(0,
    0, n - 1, l, r, x); }
    T get(int l, int r) { return _get(0, 0, n - 1, l,
    r); }

    void _build(int u, int l, int r, vector<T>& a)
    {
        if (l == r)
        {

```

```

            tree[u] = a[l];
            return;
        }

        int mid = (l + r) / 2;
        _build(left(u), l, mid, a);
        _build(right(u), mid + 1, r, a);
        tree[u] = f(tree[left(u)], tree[right(u)]);
    }

    void _update(int u, int l, int r, int i, T x)
    {
        if (l == r)
        {
            tree[u] = x;
            return;
        }

        int mid = (l + r) / 2;
        if (i <= mid) _update(left(u), l, mid, i, x);
        else _update(right(u), mid + 1, r, i, x);
        tree[u] = f(tree[left(u)], tree[right(u)]);
    }

    void propagate(int u, int l, int r)
    {
        if (lazy[u] == init_lazy || l == r) return;

        int m = (l + r) / 2;
        apply_lazy(tree[left(u)], lazy[u], l, m);
        merge_lazy(lazy[left(u)], lazy[u]);
        apply_lazy(tree[right(u)], lazy[u], m + 1, r)
        ;
        merge_lazy(lazy[right(u)], lazy[u]);

        lazy[u] = init_lazy;
    }

    void _update_range(int u, int tl, int tr, int l,
    int r, T x)
    {
        if (l > tr || r < tl) return;
        if (tl >= l && tr <= r)
        {
            apply_lazy(tree[u], x, tl, tr);
            merge_lazy(lazy[u], x);
            return;
        }

```

```

propagate(u, tl, tr);

int mid = (tl + tr) / 2;
_update_range(left(u), tl, mid, l, r, x);
_update_range(right(u), mid + 1, tr, l, r, x);
;

tree[u] = f(tree[left(u)], tree[right(u)]);
}

T _get(int u, int tl, int tr, int l, int r)
{
    if (l > tr || r < tl) return init_val;

    if (l <= tl && r >= tr) return tree[u];

    if (is_lazy) propagate(u, tl, tr);

    int mid = (tl + tr) / 2;
    return f(_get(left(u), tl, mid, l, r),
            _get(right(u), mid + 1, tr, l, r));
}

#undef left
#undef right
};

```

### 3.3 DSU

```

struct dsu
{
    vector<int> parent, size;

    dsu(int n)
    {
        parent.resize(n + 1);
        size.resize(n + 1);

        for (int i = 1; i <= n; ++i)
        {
            parent[i] = i;
            size[i] = 1;
        }
    }

    int find(int u)
    {
        if (parent[u] == u) return u;

```

```

        return parent[u] = find(parent[u]);
    }

    void merge(int u, int v)
    {
        u = find(u);
        v = find(v);

        if (u != v)
        {
            if (size[u] < size[v]) swap(u, v);
            parent[v] = u;
            size[u] += size[v];
        }
    }
};

```

## 4 Graph

### 4.1 Dijkstra

```

struct Node
{
    int u;
    ll dist;

    bool operator< (const Node& v) const
    {
        return dist > v.dist;
    }
};

void dijkstra(int start, vector<ll>& dis, vector<VPI>
>& adj)
{
    priority_queue<Node> q;
    dis[start] = 0;
    q.push({start, 0});

    while (!q.empty())
    {
        Node node = q.top();
        int u = node.u;
        q.pop();

        if (dis[u] < node.dist) continue;

        for (auto e : adj[u])

```

```

    {
        if (node.dist + e.ss < dis[e.ff])
        {
            dis[e.ff] = node.dist + e.ss;
            q.push({e.ff, dis[e.ff]});
        }
    }
}

```

### 4.2 LCA

```

int k;
VVI tree;
int step = 0;
VI vis_start, vis_end;
VVI st;

void build_st(int u, int p)
{
    st[u][0] = p;
    for (int i = 1; i <= k; ++i)
        st[u][i] = st[st[u][i - 1]][i - 1];
}

void dfs(int u, int p)
{
    vis_start[u] = step++;
    build_st(u, p);

    for (auto v : tree[u])
    {
        if (v != p) dfs(v, u);
    }

    vis_end[u] = step++;
}

bool is_ancestor(int a, int b)
{
    return vis_start[a] < vis_start[b] && vis_end[a]
        > vis_end[b];
}

int lca(int a, int b)
{
    if (a == b) return a;
    if (is_ancestor(a, b)) return a;

```

```

    if (is_ancestor(b, a)) return b;

    for (int i = k; i >= 0; --i)
    {
        if (!is_ancestor(st[a][i], b)) a = st[a][i];
    }

    return st[a][0];
}

void init(int n)
{
    vis_start.assign(n + 1, 0);
    vis_end.assign(n + 1, 0);

    k = __lg(2 * n - 1);
    st.assign(n + 1, VI(k + 1));
    dfs(1, 1);
}

```

## 4.3 SCC

```

VVI scc;
VI stk;
int disc[MAXN], low[MAXN];
bool instk[MAXN];
int cur_time;

void dfs_scc(int u, VVI& g)
{
    disc[u] = low[u] = ++cur_time;
    instk[u] = true;
    stk.pb(u);

    for (int v : g[u])
    {
        if (!disc[v])
        {
            dfs_scc(v, g);
            low[u] = min(low[u], low[v]);
        }
        else if (instk[v])
            low[u] = min(low[u], disc[v]);
    }

    if (low[u] < disc[u]) return;

    scc.pb(VI());
}

```

```

bool rem = true;
while (rem)
{
    int v = stk.back();
    stk.pop_back();
    instk[v] = false;
    scc.back().pb(v);
    rem = v != u;
}

void tarjan(VVI& g)
{
    cur_time = 0;
    int n = g.size();

    for (int i = 0; i < n; ++i) disc[i] = 0;
    for (int u = 1; u < n; ++u) if (!disc[u]) dfs_scc(u, g);
}

```

## 5 String

### 5.1 Trie

```

struct trienode
{
    bool endmark;
    vector<int> child;

    trienode(int sz)
    {
        endmark = false;
        child.resize(sz, 0);
    }
};

struct trie
{
    int sz;
    char fst;
    vector<trienode> nodes;

    trie(int alpha_sz, char alpha_start)
    {
        sz = alpha_sz;
        fst = alpha_start;
    }
}

```

```

// root at idx 0
nodes.pb(trienode(sz));
}

void insert(string& s)
{
    int cur = 0;
    for (char c : s)
    {
        if (!nodes[cur].child[c - fst])
        {
            nodes[cur].child[c - fst] = nodes.size();
            nodes.pb(trienode(sz));
        }

        cur = nodes[cur].child[c - fst];
    }

    nodes[cur].endmark = true;
}

bool search(string& s)
{
    int cur = 0;
    for (char c : s)
    {
        if (!nodes[cur].child[c - fst])
            return false;

        cur = nodes[cur].child[c - fst];
    }

    return nodes[cur].endmark;
}

bool erase(string& s)
{
    int cur = 0;
    for (char c : s)
    {
        if (!nodes[cur].child[c - fst])
            return false;

        cur = nodes[cur].child[c - fst];
    }

    if (!nodes[cur].endmark) return false;
}

```

```

        nodes[cur].endmark = false;
        return true;
    }
};

```

---

## 5.2 Z Algorithm

---

```

VI z(string s)
{
    int n = s.size();
    VI z(n);

    int l = 0, r = 0;
    for (int i = 0; i < n; ++i)
    {
        if (i <= r) z[i] = min(z[i - l], r - i + 1);

        while (i + z[i] < n && s[z[i]] == s[i + z[i]])
            l = i, r = i + z[i]++;
    }

    return z;
}

```

---

# 6 Miscellaneous

## 6.1 Generationg Permutations

---

```

VI a;
//...

sort(all(a));
do
{
    // Process permutation...
} while (next_permutation(all(a)));

```

---

## 6.2 Iterating over Submasks

---

```

int n = 17;

for (int mask = 0; mask < (1 << n); ++mask)
{
    for (int sub = mask; sub; sub = (sub - 1) & mask)
    {

```

```

        // Process submask...
    }
}

```

---

## 6.3 pbds

---

```

// ordered set
ordered_set<int> st;
// ordered multiset
ordered_set<int, less_equal<int>> multi;

// insert element
st.insert(x);
// get index
st.order_of_key(x);
// access by index
st.find_by_order(idx);

```

---