

# ICPC Notebook

template	
hash.sh .....	1
settings.sh .....	1
template.hpp .....	1
data-structure	
BIT.hpp .....	1
FastSet.hpp .....	1
LazySegmentTree.hpp .....	2
SegmentTree.hpp .....	3
SparseTable.hpp .....	3
UnionFind.hpp .....	3
waveletmatrix.hpp .....	3
math	
BinaryGCD.hpp .....	4
CHT.hpp .....	4
ChineseRem.hpp .....	5
Combination.hpp .....	5
Eratosthenes.hpp .....	5
ExtGCD.hpp .....	5
Matrix.hpp .....	5
floorsum.hpp .....	6
miller_rabin.hpp .....	6
subset_zeta.hpp .....	6
xor_set.hpp .....	7
modint	
modint.hpp .....	7
FPS	
FFT.hpp .....	7
FFT_fast.hpp .....	7
graph	
2SAT.hpp .....	8
BellmanFord.hpp .....	8
scc.hpp .....	8
graph/tree	
AuxiliaryTree.hpp .....	9
Cartesiantree.hpp .....	9
Rerooting.hpp .....	9
lca.hpp .....	10
flow	
dinic.hpp .....	11
mincostflow.hpp .....	11
燃やす埋める.md .....	11
string	
AhoCorasick.hpp .....	11
KMP.hpp .....	12
Manacher.hpp .....	12
RollingHash.hpp .....	12
SuffixArray.hpp .....	12
Trie.hpp .....	12
Zalgorithm.hpp .....	13
algorithm	
mo.hpp .....	13
geometry	
geometry.hpp .....	13
memo	
Primes.md .....	15

## template

### hash.sh

```
# 使い方: sh hash.sh -> コピペ -> Ctrl + D
# コメント・空白・改行を削除して md5 でハッシュする
g++ -dD -E -P -fpreprocessed - | tr -d '[:space:]' | md5sum |
cut -c-6
```

### settings.sh

```
# Clion の設定
Settings → Build → CMake → Reload CMake Project
add_compile_options(-D_GLIBCXX_DEBUG)
# Caps Lock を Ctrl に変更
setxkbmap -option ctrl:nocaps
```

### template.hpp

md5: 9df547

```
#include <bits/stdc++.h>
using namespace std;
using ll = long long;
const ll INF = LLONG_MAX / 4;
#define rep(i, a, b) for(ll i = a; i < (b); i++)
#define rrep(i, a, n) for(ll i = a; i >= n; i--)
#define all(a) begin(a), end(a)
#define sz(a) ssize(a)
bool chmin(auto& a, auto b) { return a > b ? a = b, 1 : 0; }
bool chmax(auto& a, auto b) { return a < b ? a = b, 1 : 0; }

int main() {
    cin.tie(0)->sync_with_stdio(0);
    // your code here...
}
```

## data-structure

### BIT.hpp

md5: 8133c8

```
struct BIT {
    vector<ll> a;
    BIT(ll n) : a(n + 1) {}
    void add(ll i, ll x) { // A[i] += x
        i++;
        while(i < sz(a)) {
            a[i] += x;
            i += i & -i;
        }
    }
    ll sum(ll r) {
        ll s = 0;
        while(r) {
            s += a[r];
            r -= r & -r;
        }
        return s;
    }
    ll sum(ll l, ll r) { // sum of A[l, r)
        return sum(r) - sum(l);
    }
};
```

### FastSet.hpp

md5: 2cb8c9

```
// using u64 = uint64_t;
const u64 B = 64;
struct FastSet {
    u64 n;
    vector<vector<u64>> a;
    FastSet(u64 n_) : n(n_) {
        do a.emplace_back(n_ = (n_ + B - 1) / B);
        while(n_ > 1);
    }
    // bool operator[](ll i) const { return a[0][i / B] >> (i % B) & 1; }
    void set(ll i) {
        for(auto& v : a) {
            v[i / B] |= 1ULL << (i % B);
        }
    }
};
```

```

        i /= B;
    }
}
void reset(ll i) {
    for(auto& v : a) {
        v[i / B] &= ~(1ULL << (i % B));
        if(v[i / B]) break;
        i /= B;
    }
}
ll next(ll i) { // i を超える最小の要素
    rep(h, 0, sz(a)) {
        i++;
        if(i / B >= sz(a[h])) break;
        u64 d = a[h][i / B] >> (i % B);
        if(d) {
            i += countr_zero(d);
            while(h--) i = i * B + countr_zero(a[h][i]);
            return i;
        }
        i /= B;
    }
    return n;
}
ll prev(ll i) { // i より小さい最大の要素
    rep(h, 0, sz(a)) {
        i--;
        if(i < 0) break;
        u64 d = a[h][i / B] << (~i % B);
        if(d) {
            i -= countl_zero(d);
            while(h--) i = i * B + __lg(a[h][i]);
            return i;
        }
        i /= B;
    }
    return -1;
}
};

```

## LazySegmentTree.hpp

md5: 4c6574

```

template<class T,
        T (*op)(const T&, const T&),
        T (*e)(),
        class F,
        T (*mapping)(const F&, const T&),
        F (*composition)(const F&, const F&),
        F (*id)()>
struct LazySegmentTree {
    LazySegmentTree(const int _n) : n(_n) {
        while((1 << log) < n) log++;
        len = 1 << log;
        d.assign(len * 2, e());
        lazy.assign(len, id());
    }
    void set(const int i, const T& x) {
        assert(0 <= i && i < n);
        d[i + len] = x;
    }
    T get(int p) {
        assert(0 <= p && p < n);
        p += len;
        for(int i = log; i >= 1; i--) push(p >> i);
        return d[p];
    }
    void build() {
        for(int i = len - 1; i >= 1; i--) update(i);
    }
    void update(int l, int r, const F& x) {
        assert(0 <= l && l <= r && r <= n);
        l += len;
        r += len;
        const int l_ctz = __builtin_ctz(l);
        const int r_ctz = __builtin_ctz(r);
        for(int i = log; i > l_ctz; i--) push(l >> i);
        for(int i = log; i > r_ctz; i--) push((r - 1) >> i);
        const int lt = l, rt = r;
        while(l < r) {
            if(l & 1) apply(l++, x);
            if(r & 1) apply(--r, x);
            l >>= 1;

```

```

            r >>= 1;
        }
        l = lt;
        r = rt;
        for(int i = l_ctz + 1; i <= log; i++) update(l >> i);
        for(int i = r_ctz + 1; i <= log; i++) update((r - 1) >>
i);
    }
    T query(int l, int r) {
        assert(0 <= l && l <= r && r <= n);
        l += len;
        r += len;
        const int l_ctz = __builtin_ctz(l);
        const int r_ctz = __builtin_ctz(r);
        for(int i = log; i > l_ctz; i--) push(l >> i);
        for(int i = log; i > r_ctz; i--) push((r - 1) >> i);
        T left = e(), right = e();
        while(l < r) {
            if(l & 1) left = op(left, d[l++]);
            if(r & 1) right = op(d[--r], right);
            l >>= 1;
            r >>= 1;
        }
        return op(left, right);
    }
}
template<class G> int max_right(int l, G g) {
    assert(0 <= l && l <= n);
    assert(g(e()));
    if(l == n) return n;
    l += len;
    for(int i = log; i >= 1; i--) push(l >> i);
    T sm = e();
    do {
        l /= l & -l;
        if(!g(op(sm, d[l]))) {
            while(l < len) {
                push(l);
                l <<= 1;
                if(g(op(sm, d[l]))) {
                    sm = op(sm, d[l]);
                    l++;
                }
            }
            return l - len;
        }
        sm = op(sm, d[l]);
        l++;
    } while(l & (l - 1));
    return n;
}
template<class G> int min_left(int r, G g) {
    assert(0 <= r && r <= n);
    assert(g(e()));
    if(r == 0) return 0;
    r += len;
    for(int i = log; i >= 1; i--) push((r - 1) >> i);
    T sm = e();
    do {
        r /= r & -r;
        if(r > 1) r--;
        if(!g(op(d[r], sm))) {
            while(r < len) {
                push(r);
                r = r * 2 + 1;
                if(g(op(d[r], sm))) {
                    sm = op(d[r], sm);
                    r--;
                }
            }
            return r + 1 - len;
        }
        sm = op(d[r], sm);
    } while(r & (r - 1));
    return 0;
}
private:
vector<T> d;
vector<F> lazy;
int n = 1, log = 0, len = 0;
inline void update(const int k) { d[k] = op(d[2 * k], d[2 *
k + 1]); }

```

```
inline void apply(const int k, const F& x) {
    d[k] = mapping(x, d[k]);
    if(k < len) lazy[k] = composition(lazy[k], x);
}
inline void push(const int k) {
    apply(2 * k, lazy[k]);
    apply(2 * k + 1, lazy[k]);
    lazy[k] = id();
}
};
```

SegmentTree.hpp

md5: 0f4bdb

```
struct Tree {
    typedef int T;
    static constexpr T unit = INT_MIN;
    T f(T a, T b) { return max(a, b); } // (any associative fn)
    vector<T> s;
    int n;
    Tree(int n = 0, T def = unit) : s(2 * n, def), n(n) {}
    void update(int pos, T val) {
        for(s[pos += n] = val; pos /= 2;) s[pos] = f(s[pos * 2],
s[pos * 2 + 1]);
    }
    T query(int b, int e) { // query [b, e)
        T ra = unit, rb = unit;
        for(b += n, e += n; b < e; b /= 2, e /= 2) {
            if(b % 2) ra = f(ra, s[b++]);
            if(e % 2) rb = f(s[--e], rb);
        }
        return f(ra, rb);
    }
};
```

SparseTable.hpp

md5: acd1f4

```
template<typename T> struct SparseTable {
    vector<vector<T>> > st;
    vector<int> lookup;

    SparseTable(const vector<T>& v) {
        int b = 0;
        while((1 << b) <= v.size()) ++b;
        st.assign(b, vector<T>(1 << b));
        for(int i = 0; i < v.size(); i++) { st[0][i] = v[i]; }
        for(int i = 1; i < b; i++) {
            for(int j = 0; j + (1 << i) <= (1 << b); j++) { st[i]
[j] = min(st[i - 1][j], st[i - 1][j + (1 << (i - 1))]); }
        }
        lookup.resize(v.size() + 1);
        for(int i = 2; i < lookup.size(); i++) { lookup[i] =
lookup[i >> 1] + 1; }

        inline T rmq(int l, int r) {
            int b = lookup[r - l];
            return min(st[b][l], st[b][r - (1 << b)]);
        }
    };
};
```

UnionFind.hpp

md5: 17bc86

```
struct UF {
    vector<int> e;
    UF(int n) : e(n, -1) {}
    bool sameSet(int a, int b) { return find(a) == find(b); }
    int size(int x) { return -e[find(x)]; }
    int find(int x) { return e[x] < 0 ? x : e[x] = find(e[x]); }
    bool join(int a, int b) {
        a = find(a), b = find(b);
        if(a == b) return false;
        if(e[a] > e[b]) swap(a, b);
        e[a] += e[b];
        e[b] = a;
        return true;
    }
};
```

waveletmatrix.hpp

md5: 3b1bf0

```
// i桁目のビットが1かどうか
bool has_bit(ll x, int i) { return (x >> i) & 1; }

// 長さnの静的なビット列に対して累積和ができるデータ構造
class BitCumulativeSum {
    // 64桁ごとに累積和を作る
    inline static constexpr int w = 64;

    vector<uint64_t> block; // ビット列をwごとに保持
    vector<int> sum; // 累積和

public:
    BitCumulativeSum() = default;
    BitCumulativeSum(int n) : block(n / w + 1, 0), sum(1, 0) {
        sum.reserve(block.size() + 1); // 事前に要素数分のメモリを確保しておく（このサイズになっているわけではない）
    }

    // i桁目のビットを立てる
    void set(int i) { block[i / w] |= 1LL << (i % w); }

    // 累積和を作成
    void build() {
        for(const auto& b : block) {
            // popcount : 2進数表記で1の数を数える
            sum.push_back(sum.back() + popcount(b));
        }
    }

    // [0, r) 桁までの1の個数
    int rank1(int r) const { return sum[r / w] +
popcount(block[r / w] & ((1LL << (r % w)) - 1)); }

    // [0, r) 桁まででの0の個数
    int rank0(int r) const { return r - rank1(r); }
};

// 本題
class WaveletMatrix {
    int n, sigma;
    vector<BitCumulativeSum> bv;

public:
    WaveletMatrix(vector<int> v) : n((int)v.size()) {
        // sigmaを決定する
        int mx = 0;
        for(auto& x : v) {
            assert(x >= 0);
            mx = max(mx, x);
        }
        sigma = 0;
        while((1LL << sigma) - 1 < mx) sigma++;

        // 行列の構築
        bv.assign(sigma, n);
        vector<int> nxt_v(n);
        // 上位の桁から構築していく
        for(int h = sigma - 1; h >= 0; h--) {
            auto& B = bv[h]; // h桁目に対応するビットの累積和（ただし0の個数を数える）

            // vでh桁目が0の要素を左に、1の要素を右に寄せる
            int l = 0, r = n - 1;
            // 1の方を寄せる
            for(int i = n - 1; i >= 0; i--) {
                if(has_bit(v[i], h)) {
                    B.set(i);
                    nxt_v[r--] = v[i];
                }
            }

            B.build(); // 累積和を構築

            // 0の方も寄せる
            for(int i = 0; i < n; i++) {
                if(!has_bit(v[i], h)) { nxt_v[l++] = v[i]; }
            }
        }
    }
};
```

```
        swap(v, nxt_v);
    }
}

// [l, r) でk番目に小さい数 (0-indexed)
int kth_smallest(int l, int r, int k) const {
    assert(0 <= k && k < n);
    uint32_t res = 0;
    // 上位の桁から0か1を決定していく
    for(int h = sigma - 1; h >= 0; h--) {
        const auto& B = bv[h];
        int zero_cnt = B.rank0(r) - B.rank0(l); // 区間のビット
0の個数

        if(k >= zero_cnt) {
            // h桁目が1の場合
            res |= 1 << h;
            k -= zero_cnt;
            // 区間の更新
            // h桁目が0の要素が左、1の要素が右によっていることを利用する
            l = B.rank0(n) + B.rank1(l);
            r = B.rank0(n) + B.rank1(r);
        } else {
            // h桁目が0の場合
            l = B.rank0(l);
            r = B.rank0(r);
        }
    }
    return res;
}

// [l, r) でk番目に小さい数 (0-indexed)
int kth_largest(int l, int r, int k) const {
    assert(0 <= r - l - k + 1 && r - l - k + 1 < n);
    return kth_smallest(l, r, r - l - k + 1);
}

// [0, r) でu未満の値の個数
int range_freq(int r, int u) {
    assert(u >= 0);
    if(u >= (1LL << sigma)) return r;

    int l = 0, ret = 0;
    for(int h = sigma - 1; h >= 0; --h) {
        auto& B = bv[h];
        if(has_bit(u, h)) {
            // h桁目が1の場合
            ret += B.rank0(r) - B.rank0(l); // 区間に属しているh
桁目が0の要素はu未満
            l = B.rank0(n) + B.rank1(l);
            r = B.rank0(n) + B.rank1(r);
        } else {
            // h桁目が0の場合
            l = B.rank0(l);
            r = B.rank0(r);
        }
    }

    return ret;
}

// [l, r) でu未満の値の個数
int range_freq(int l, int r, int u) {
    assert(u >= 0);
    return range_freq(r, u) - range_freq(l, u);
}

// [l, r) でd以上u未満の値の個数
int range_freq(int l, int r, int d, int u) {
    assert(d >= 0 && u >= 0);
    return range_freq(l, r, u) - range_freq(l, r, d);
};
```

BinaryGCD.hpp

md5: f3ab31

```
u64 ctz(u64 x) { return countr_zero(x); }
u64 binary_gcd(u64 x, u64 y) {
```

```
    if(!x || !y) return x | y;
    u64 n = ctz(x), m = ctz(y);
    x >>= n, y >>= m;
    while(x != y) {
        if(x > y) x = (x - y) >> ctz(x - y);
        else y = (y - x) >> ctz(y - x);
    }
    return x << min(n, m);
}

}



CHT.hpp



md5: b42f8f



```
template<typename T> class CHT {
private:
    struct node {
        node *left, *right;
        static const T inf = numeric_limits<T>::max();
        T a, b;
        node() : node(0, inf) {}
        node(const T _a, const T _b) : left(nullptr),
right(nullptr), a(_a), b(_b) {}
        T f(const T x) const { return a * x + b; }
    };

    static void swap(node* x, node* y) { std::swap(x->a, y->a),
std::swap(x->b, y->b); }
    void _add_line(node* cur, node* nw, T l, T r) {
        while(true) {
            if(nw->f(l) < cur->f(l)) swap(cur, nw);
            if(cur->f(r - 1) <= nw->f(r - 1)) break;
            const T mid = (l + r) / 2;
            if(cur->f(mid) <= nw->f(mid)) {
                if(!cur->right) {
                    cur->right = new node(*nw);
                    break;
                } else {
                    cur = cur->right, l = mid;
                }
            } else {
                swap(cur, nw);
                if(!cur->left) {
                    cur->left = new node(*nw);
                    break;
                } else {
                    cur = cur->left, r = mid;
                }
            }
        }
    }
}

T query(node* cur, const T k, T l, T r) const {
    T ans = numeric_limits<T>::max();
    while(cur) {
        ans = min(ans, cur->f(k));
        const T mid = (l + r) / 2;
        if(k < mid) {
            cur = cur->left, r = mid;
        } else {
            cur = cur->right, l = mid;
        }
    }
    return ans;
}

void clear(node* cur) {
    if(cur->left) clear(cur->left);
    if(cur->right) clear(cur->right);
    delete cur;
}

const T lpos, rpos;
node* root;

public:
    CHT(const T _lpos, const T _rpos) : lpos(_lpos),
rpos(_rpos), root(new node()) { assert(lpos < rpos); }
    // ~CHT(){ clear(root); }
    // f(x) = a * x + b を挿入
    void add_line(const T a, const T b) {
        node nw(a, b);
        return _add_line(root, &nw, lpos, rpos);
    }
    // x = k での最小値
    T query(const T k) const { return query(root, k, lpos,
```


```

```
rpos); }
};
```

ChineseRem.hpp

md5: b8b1f7

```
inline ll mod(ll a, ll m) { return (a % m + m) % m; }

inline long long mul(long long a, long long b, long long m) {
    a = mod(a, m);
    b = mod(b, m);
    if(b == 0) return 0;
    long long res = mul(mod(a + a, m), b >> 1, m);
    if(b & 1) res = mod(res + a, m);
    return res;
}

// 拡張ユークリッドの互除法
// ap+bq=gcd(a, b) となる (p, q) を求め、d = gcd(a, b) をリターンし
ます。
ll extGCD(ll a, ll b, ll& p, ll& q) {
    if(b == 0) {
        p = 1;
        q = 0;
        return a;
    }
    ll d = extGCD(b, a % b, q, p);
    q -= a / b * p;
    return d;
}

// 中国剰余定理
// リターン値を (r, m) とすると解は x = r (mod. m)
// 解なしの場合は (0, -1) をリターン
pll chineseRem(const vector<ll>& b, const vector<ll>& m) {
    ll r = 0, M = 1;
    rep(i, 0, (int)b.size()) {
        ll p, q;
        ll d = extGCD(M, m[i], p, q); // p is inv of m1/d (mod.
m[i]/d)
        if((b[i] - r) % d != 0) return {0, -1};
        ll tmp = mul(((b[i] - r) / d), p, (m[i] / d));
        r += M * tmp;
        M *= m[i] / d;
    }
    return {mod(r, M), M};
}
```

Combination.hpp

md5: a88ecc

```
int maxnum = 200005;
vector<ll> fac(maxnum), inv(maxnum), finv(maxnum);
void init_fac() {
    fac[0] = fac[1] = 1;
    inv[1] = 1;
    finv[0] = finv[1] = 1;
    rep(i, 2, maxnum) {
        fac[i] = fac[i - 1] * i % MOD;
        inv[i] = MOD - MOD / i * inv[MOD % i] % MOD;
        finv[i] = finv[i - 1] * inv[i] % MOD;
    }
}
ll nCr(ll n, ll r) {
    if(n < 0 or n - r < 0 or r < 0) return 0;
    return fac[n] * (finv[n - r] * finv[r] % MOD) % MOD;
}
```

Eratosthenes.hpp

md5: 880810

```
int max_num = 1000005;
vector<int> erat(max_num);
void init_e() {
    rep(i, 2, sqrt(max_num - 1)) {
        if(erat[i] == 0) {
            for(int j = i * i; j <= max_num - 1; j += i) {
                if(erat[j] == 0) erat[j] = i;
            }
        }
    }
}
```

ExtGCD.hpp

md5: c3fa9b

```
// returns gcd(a, b) and assign x, y to integers
// s.t. ax + by = gcd(a, b) and |x| + |y| is minimized
ll extgcd(ll a, ll b, ll& x, ll& y) {
    // assert(a >= 0 && b >= 0);
    if(!b) return x = 1, y = 0, a;
    ll d = extgcd(b, a % b, y, x);
    y -= a / b * x;
    return d;
}
```

Matrix.hpp

md5: 25fbc4

```
template<class T> struct Matrix {
    vector<vector<T>> A;

    Matrix() {}

    Matrix(size_t n, size_t m) : A(n, vector<T>(m, 0)) {}

    Matrix(size_t n) : A(n, vector<T>(n, 0)){};

    size_t height() const { return A.size(); }

    size_t width() const { return A[0].size(); }

    inline const vector<T>& operator[](ll k) const { return
(A.at(k)); }

    inline vector<T>& operator[](ll k) { return (A.at(k)); }

    static Matrix I(size_t n) {
        Matrix mat(n);
        for(ll i = 0; i < n; i++) mat[i][i] = 1;
        return (mat);
    }

    Matrix& operator+=(const Matrix& B) {
        size_t n = height(), m = width();
        assert(n == B.height() && m == B.width());
        for(ll i = 0; i < n; i++)
            for(ll j = 0; j < m; j++) (*this)[i][j] += B[i][j];
        return (*this);
    }

    Matrix& operator-=(const Matrix& B) {
        size_t n = height(), m = width();
        assert(n == B.height() && m == B.width());
        for(ll i = 0; i < n; i++)
            for(ll j = 0; j < m; j++) (*this)[i][j] -= B[i][j];
        return (*this);
    }

    Matrix& operator*=(const Matrix& B) {
        size_t n = height(), m = B.width(), p = width();
        assert(p == B.height());
        vector<vector<T>> C(n, vector<T>(m, 0));
        for(ll i = 0; i < n; i++)
            for(ll j = 0; j < m; j++)
                for(ll k = 0; k < p; k++) C[i][j] = (C[i][j] +
(*this)[i][k] * B[k][j]);
        A.swap(C);
        return (*this);
    }

    Matrix& operator^=(long long k) {
        Matrix B = Matrix::I(height());
        while(k > 0) {
            if(k & 1) B *= *this;
            *this *= *this;
            k >>= 1LL;
        }
        A.swap(B.A);
        return (*this);
    }

    Matrix operator+(const Matrix& B) const { return
(Matrix(*this) += B); }

    Matrix operator-(const Matrix& B) const { return
```

```
(Matrix(*this) -= B); }
```

```
Matrix operator*(const Matrix& B) const { return
(Matrix(*this) *= B); }
```

```
Matrix operator^(const long long k) const { return
(Matrix(*this) ^= k); }
```

```
// 行列式
T determinant() {
    Matrix B(*this);
    assert(width() == height());
    T ret = 1;
    for(ll i = 0; i < width(); i++) {
        ll idx = -1;
        for(ll j = i; j < width(); j++) {
            if(B[j][i] != 0) idx = j;
        }
        if(idx == -1) return 0;
        if(i != idx) {
            ret *= -1;
            swap(B[i], B[idx]);
        }
        ret *= B[i][i];
        T vv = B[i][i];
        for(ll j = 0; j < width(); j++) { B[i][j] /= vv; }
        for(ll j = i + 1; j < width(); j++) {
            T a = B[j][i];
            for(ll k = 0; k < width(); k++) { B[j][k] -= B[i]
[k] * a; }
        }
    }
    return (ret);
}

ll rank() {
    vector<vector<T>> B = A;
    ll n = B.size();
    ll m = B[0].size();
    rep(i, 0, n) {
        ll id = i;
        rep(j, i + 1, n) if(B[id] < B[j]) id = j;
        swap(B[i], B[id]);
        ll r = -1;
        rep(j, i, m) if(B[i][j]) {
            r = j;
            break;
        }
        if(r == -1) return i;
        rep(j, 0, n) {
            if(i == j) continue;
            if(B[j][r]) { rep(k, i, m) B[j][k] ^= B[i][k]; }
        }
    }
    return n;
}
};
```

floorsum.hppmd5: 76b016

```
long long floor_sum(long long n, long long m, long long a, long
long b) {
    long long ans = 0;
    if(a >= m) {
        ans += (n - 1) * n * (a / m) / 2;
        a %= m;
    }
    if(b >= m) {
        ans += n * (b / m);
        b %= m;
    }

    long long y_max = (a * n + b) / m, x_max = (y_max * m - b);
    if(y_max == 0) return ans;
    ans += (n - (x_max + a - 1) / a) * y_max;
    ans += floor_sum(y_max, a, m, (a - x_max % a) % a);
}

}
```

miller\_rabin.hppmd5: b6e3d4

```
ll mod_pow(ll a, ll b, ll m) {
    ll res = 1;
    a %= m;
    while(b > 0) {
        if(b & 1) res = __uint128_t(res) * a % m;
        a = __uint128_t(a) * a % m;
        b >>= 1;
    }
    return res;
}

// num が素数なら true, そうでなければ false (計算量 O(log{num}^3))
bool miller_rabin(ll num) {
    const vector<ll> A = {2, 325, 9375, 28178, 450775, 9780504,
1795265022};

    // これらは例外的に判定が必要 (なぜかは分らん)
    if(num == 2 || num == 3 || num == 5 || num == 13 || num ==
19 || num == 73 || num == 193 || num == 407521
|| num == 299210837)
        return true;
    // 1 か 2 以外の偶数は素数でない
    if(num == 1 || !(num & 1)) return false;

    // num-1 = 2^s d (d は奇数) を満たす s, d を求める
    ll s = 0, d = num - 1;
    while(!(d & 1)) { s = s + 1, d >>= 1; }

    // 各 a について, 条件をチェックする
    for(auto a : A) {
        ll powa = mod_pow(a, d, num);
        if(powa == 1 || powa == num - 1) continue;

        bool may_prime = false;
        for(int i = 0; i < s - 1; i++) {
            powa = __uint128_t(powa) * powa % num;
            if(powa == 1) return false;
            if(powa == num - 1) {
                may_prime = true;
                break;
            }
        }
        if(!may_prime) return false;
    }

    return true;
}
```

subset\_zeta.hppmd5: 748007

```
template<class T> vector<T> subset_zeta(vector<T> f, int n,
bool inv = false) {
    for(int i = 0; i < n; i++) {
        for(int S = 0; S < (1 << n); S++) {
            if((S & (1 << i)) != 0) { // if i in S
                if(!inv) {
                    f[S] += f[S ^ (1 << i)];
                } else {
                    f[S] -= f[S ^ (1 << i)];
                }
            }
        }
    }
    return f;
}

template<class T> vector<T> supset_zeta(vector<T> f, int n,
bool inv = false) {
    for(int i = 0; i < n; i++) {
        for(int S = 0; S < (1 << n); S++) {
            if((S & (1 << i)) == 0) { // if i not in S
                if(!inv) {
                    f[S] += f[S ^ (1 << i)];
                } else {
                    f[S] -= f[S ^ (1 << i)];
                }
            }
        }
    }
}
```

```
        return f;
    }
}

xor_set.hpp
md5: 70bacd

class xor_set {
private:
    vector<ll> w;

public:
    xor_set() {}
    void insert(ll x) {
        for(ll v : w)
            if(v & -v & x) x ^= v;
        if(x == 0) return;
        for(ll& v : w)
            if(x & -x & v) v ^= x;
        w.push_back(x);
    }
    // 独立か判定
    ll count(ll x) {
        for(ll v : w)
            if(v & -v & x) x ^= v;
        if(x == 0) return 1;
        else return 0;
    }
    vector<ll> get() { return w; }
};
```

```
modint
md5: 81b530

modint.hpp
md5: 81b530

const ll mod = 998244353;
struct mm {
    ll x;
    mm(ll x_ = 0) : x(x_ % mod) {
        if(x < 0) x += mod;
    }
    friend mm operator+(mm a, mm b) { return a.x + b.x; }
    friend mm operator-(mm a, mm b) { return a.x - b.x; }
    friend mm operator*(mm a, mm b) { return a.x * b.x; }
    friend mm operator/(mm a, mm b) { return a * b.inv(); }
    // 4 行コピー Alt + Shift + クリックで複数カーソル
    friend mm& operator+=(mm& a, mm b) { return a = a.x + b.x; }
    friend mm& operator-=(mm& a, mm b) { return a = a.x - b.x; }
    friend mm& operator*=(mm& a, mm b) { return a = a.x * b.x; }
    friend mm& operator/=(mm& a, mm b) { return a = a * b.inv(); }
}

mm inv() const { return pow(mod - 2); }
mm pow(ll b) const {
    mm a = *this, c = 1;
    while(b) {
        if(b & 1) c *= a;
        a *= a;
        b >>= 1;
    }
    return c;
}
};
```

```
FPS
md5: 3138c7

FFT.hpp
md5: 3138c7

// {998244353, 3}, {1811939329, 13}, {2013265921, 31}
mm g = 3; // 原始根
void fft(vector<mm>& a) {
    ll n = sz(a), lg = __lg(n);
    assert((1 << lg) == n);
    vector<mm> b(n);
    rep(l, 1, lg + 1) {
        ll w = n >> l;
        mm s = 1, r = g.pow(mod >> l);
        for(ll u = 0; u < n / 2; u += w) {
            rep(d, 0, w) {
                mm x = a[u << 1 | d], y = a[u << 1 | w | d] * s;
                b[u | d] = x + y;
                b[n >> 1 | u | d] = x - y;
            }
        }
    }
}
```

```
        s *= r;
    }
    swap(a, b);
}
}

vector<mm> conv(vector<mm> a, vector<mm> b) {
    if(a.empty() || b.empty()) return {};
    size_t s = sz(a) + sz(b) - 1, n = bit_ceil(s);
    // if(min(sz(a), sz(b)) <= 60) 愚直に掛け算
    a.resize(n);
    b.resize(n);
    fft(a);
    fft(b);
    mm inv = mm(n).inv();
    rep(i, 0, n) a[i] *= b[i] * inv;
    reverse(1 + all(a));
    fft(a);
    a.resize(s);
    return a;
}
}
```

```
FFT_fast.hpp
md5: c8c567

// modint を u32 にして加減算を真面目にやると速い
mm g = 3; // 原始根
void fft(vector<mm>& a) {
    ll n = sz(a), lg = __lg(n);
    static auto z = [] {
        vector<mm> z(30);
        mm s = 1;
        rep(i, 2, 32) {
            z[i - 2] = s * g.pow(mod >> i);
            s = g.inv().pow(mod >> i);
        }
        return z;
    }();
    rep(l, 0, lg) {
        ll w = 1 << (lg - l - 1);
        mm s = 1;
        rep(k, 0, 1 << l) {
            ll o = k << (lg - l);
            rep(i, o, o + w) {
                mm x = a[i], y = a[i + w] * s;
                a[i] = x + y;
                a[i + w] = x - y;
            }
            s = z[countr_zero<uint64_t>(~k)];
        }
    }
}

// コピー
void ifft(vector<mm>& a) {
    ll n = sz(a), lg = __lg(n);
    static auto z = [] {
        vector<mm> z(30);
        mm s = 1;
        rep(i, 2, 32) { // g を逆数に
            z[i - 2] = s * g.inv().pow(mod >> i);
            s = g.pow(mod >> i);
        }
        return z;
    }();
    for(ll l = lg; l--;) { // 逆順に
        ll w = 1 << (lg - l - 1);
        mm s = 1;
        rep(k, 0, 1 << l) {
            ll o = k << (lg - l);
            rep(i, o, o + w) {
                mm x = a[i], y = a[i + w]; // *s を下に移動
                a[i] = x + y;
                a[i + w] = (x - y) * s;
            }
            s = z[countr_zero<uint64_t>(~k)];
        }
    }
}

vector<mm> conv(vector<mm> a, vector<mm> b) {
    if(a.empty() || b.empty()) return {};
    size_t s = sz(a) + sz(b) - 1, n = bit_ceil(s);
    // if(min(sz(a), sz(b)) <= 60) 愚直に掛け算
    a.resize(n);
    b.resize(n);
    fft(a);
    fft(b);
    mm inv = mm(n).inv();
    rep(i, 0, n) a[i] *= b[i] * inv;
    reverse(1 + all(a));
    fft(a);
    a.resize(s);
    return a;
}
}
```



```
b.resize(n);
fft(a);
fft(b);
mm inv = mm(n).inv();
rep(i, 0, n) a[i] *= b[i] * inv;
ifft(a);
a.resize(s);
return a;
}
```

## graph

### 2SAT.hpp

md5: fde404

```
struct TwoSat {
    int N;
    vector<vector<int>> gr;
    vector<int> values; // 0 = false, 1 = true

    TwoSat(int n = 0) : N(n), gr(2 * n) {}

    int addVar() { // (optional)
        gr.emplace_back();
        gr.emplace_back();
        return N++;
    }
    // (f v j)
    void either(int f, int j) {
        f = max(2 * f, -1 - 2 * j);
        j = max(2 * j, -1 - 2 * f);
        gr[f].push_back(j ^ 1);
        gr[j].push_back(f ^ 1);
    }
    // x は真
    void setValue(int x) { either(x, x); }
    // li の中から高々1つ真
    void atMostOne(const vector<int>& li) { // (optional)
        if(sz(li) <= 1) return;
        int cur = ~li[0];
        rep(i, 2, sz(li)) {
            int next = addVar();
            either(cur, ~li[i]);
            either(cur, next);
            either(~li[i], next);
            cur = ~next;
        }
        either(cur, ~li[1]);
    }

    vector<int> val, comp, z;
    int time = 0;
    int dfs(int i) {
        int low = val[i] = ++time, x;
        z.push_back(i);
        for(int e : gr[i])
            if(!comp[e]) low = min(low, val[e] ?: dfs(e));
        if(low == val[i]) do {
            x = z.back();
            z.pop_back();
            comp[x] = low;
            if(values[x >> 1] == -1) values[x >> 1] = x & 1;
        } while(x != i);
        return val[i] = low;
    }

    bool solve() {
        values.assign(N, -1);
        val.assign(2 * N, 0);
        comp = val;
        rep(i, 0, 2 * N) if(!comp[i]) dfs(i);
        rep(i, 0, N) if(comp[2 * i] == comp[2 * i + 1]) return 0;
        return 1;
    }
};
```

### BellmanFord.hpp

md5: 52c2ea

```
struct Edge {
    ll from;
    ll to;
    ll cost;
```

```
};
```

```
// ベルマンフォード法 (基本実装)
// 負閉路が存在する場合 true を返す
// distances は頂点数と同じサイズ, 全要素 INF で初期化しておく
bool BellmanFord(vector<Edge>& edges, vector<ll>& dist, ll
start) {
    fill(dist.begin(), dist.end(), INF);
    dist[start] = 0;
    // 負の閉路がなければ、(頂点数-1)回の更新で最短路が決まる
    rep(i, 0, (ll)dist.size()) {
        bool changed = false;
        // 各辺について
        for(const auto& edge : edges) {
            // to までの新しい距離
            const ll d = (dist[edge.from] + edge.cost);
            // d が現在の記録より小さければ更新
            if(d < dist[edge.to] && dist[edge.from] != INF) {
                dist[edge.to] = d;
                changed = true;
            }
        }
        if(!changed) { return false; }
    }
    // 負閉路が影響を与える範囲を計算
    // rep(i, 0, (ll)dist.size()){
    //     // 各辺について
    //     for (const auto& edge : edges){
    //         // to までの新しい距離
    //         const ll d = (dist[edge.from] + edge.cost);
    //         // d が現在の記録より小さければ更新
    //         if (d < dist[edge.to]&& dist[edge.from] != INF)
    {
        //             dist[edge.to] = -INF;
        //         }
        //     }
    // }
    // 頂点回数分だけループしても更新が続くのは、負閉路が存在するから
    return true;
}
```

### scc.hpp

md5: d48735

```
struct StronglyConnectedComponents {
    ll n;
    vector<vector<ll>> G, rG;
    vector<ll> order, component;
    vector<bool> used;
    void dfs(ll v) {
        used[v] = 1;
        for(auto nv : G[v]) {
            if(!used[nv]) dfs(nv);
        }
        order.push_back(v);
    }
    void rdfs(ll v, ll k) {
        component[v] = k;
        for(auto nv : rG[v]) {
            if(component[nv] < 0) rdfs(nv, k);
        }
    }

    StronglyConnectedComponents(vector<vector<ll>>& _G) {
        n = _G.size();
        G = _G;
        rG.resize(n);
        component.assign(n, -1);
        used.resize(n);
        for(ll v = 0; v < n; v++) {
            for(auto nv : G[v]) rG[nv].push_back(v);
        }
        for(ll v = 0; v < n; v++)
            if(!used[v]) dfs(v);
        ll k = 0;
        reverse(order.begin(), order.end());
        for(auto v : order)
            if(component[v] == -1) rdfs(v, k), k++;
    }
}
```

/// 頂点(u, v)が同じ強連結成分に含まれるか



```
bool is_same(ll u, ll v) { return component[u] == component[v]; }

// 強連結成分を1つのノードに潰したグラフを再構築する
vector<vector<ll>> rebuild() {
    ll N = *max_element(component.begin(), component.end()) + 1;

    vector<vector<ll>> rebuilddG(N);
    set<pair<ll, ll>> connected;
    for(ll v = 0; v < n; v++) {
        for(auto nv : G[v]) {
            if(component[v] != component[nv] and
!connected.count(pair(v, nv))) {
                connected.insert(pair(v, nv));
            }
        }
    }

    rebuilddG[component[v]].push_back(component[nv]);
}

vector<vector<ll>> scc() {
    unordered_map<ll, vector<ll>> mp;
    rep(i, 0, n) mp[component[i]].push_back(i);
    vector<vector<ll>> res;
    for(auto [key, val] : mp) res.push_back(val);
    return res;
}
};
```

graph/tree

AuxiliaryTree.hpp

md5: 1e46db

```
vector<int> fs, ls, depth, lg, stk;

vector<vector<int>> st;
int cur;
vector<vector<int>> graph;

void ett_dfs(int v, int p, int d) {
    st[0][fs[v] = cur++] = v;
    depth[v] = d;
    for(int w : graph[v]) {
        if(w == p) continue;
        ett_dfs(w, v, d + 1);
        st[0][cur++] = v;
    }
    ls[v] = cur - 1;
}

void AuxiliaryTree(vector<vector<int>> gh) {
    graph = gh;
    int n = graph.size();
    fs.resize(n);
    ls.resize(n);
    depth.resize(n);
    lg.resize(3 * n);
    stk.resize(2 * n);
    st.resize(20);
    for(int i = 0; i < 20; i++) st[i].resize(3 * n);
    cur = 0;
    ett_dfs(0, -1, 0);
    lg[0] = lg[1] = 0;
    for(int i = 2; i <= cur; ++i) lg[i] = lg[i >> 1] + 1;

    for(int i = 0, b = 1; i < lg[cur]; ++i, b <= 1) {
        for(int j = 0; j < (cur - (b << 1) + 1); ++j) {
            st[i + 1][j] = (depth[st[i][j]] <= depth[st[i][j + b]])
? st[i][j] : st[i][j + b];
        }
    }
}

bool cmp_at(int x, int y) { return fs[x] < fs[y]; }

inline int lca(int u, int v) {
    int x = fs[u], y = fs[v];
    if(x > y) swap(x, y);
    int l = lg[y - x + 1];
```

```
return (depth[st[l][x]] <= depth[st[l][y - (1 << l) + 1]]) ?
st[l][x] : st[l][y - (1 << l) + 1]);
}

// 頂点vsを含むAuxiliary Treeを構築する
// 結果をg0に入れる
// 根頂点を返す
inline int auxiliary_tree(vector<int>& vs, vector<vector<int>>&
g0) {
    sort(vs.begin(), vs.end(), cmp_at);
    int k = vs.size();
    for(int i = 0; i < k - 1; ++i) { vs.push_back(lca(vs[i],
vs[i + 1])); }
    sort(vs.begin(), vs.end(), cmp_at);
    int prv = -1;
    int cur = 0;
    for(int i = 0; i < vs.size(); ++i) {
        int v = vs[i];
        if(prv == v) continue;
        while(cur > 0 && ls[stk[cur - 1]] < fs[v]) --cur;
        if(cur > 0) {
            g0[stk[cur - 1]].push_back(v);
            g0[v].push_back(stk[cur - 1]);
        }
        // 有向
        // if(cur > 0) {
        //     g0[stk[cur-1]].push_back(v);
        // }
        // g0[v].clear();
        stk[cur++] = v;
        prv = v;
    }
    return stk[0];
}
```

Cartesiantree.hpp

md5: 41ed07

```
template<typename T> pair<vector<vector<int>>, int>
CartesianTree(vector<T>& a) {
    int N = (int)a.size();
    vector<vector<int>> g(N);
    vector<int> p(N, -1), st;
    st.reserve(N);
    for(int i = 0; i < N; i++) {
        int prv = -1;
        while(!st.empty() && a[i] < a[st.back()]) {
            prv = st.back();
            st.pop_back();
        }
        if(prv != -1) p[prv] = i;
        if(!st.empty()) p[i] = st.back();
        st.push_back(i);
    }
    int root = -1;
    for(int i = 0; i < N; i++) {
        if(p[i] != -1) g[p[i]].push_back(i);
        else root = i;
    }
    return make_pair(g, root);
}
```

Rerooting.hpp

md5: 866b81

```
template<class E, class V, E (*merge)(E, E), E (*e)(), E
(*put_edge)(V, int), V (*put_vertex)(E, int)>
struct RerootingDP {
    struct edge {
        int to, idx, xdi;
    };
    RerootingDP(int n_ = 0) : n(n_), inner_edge_id(0) {
        es.resize(2 * n - 2);
        start.resize(2 * n - 2);
        if(n == 1) es_build();
    }
    void add_edge(int u, int v, int idx, int xdi) {
        start[inner_edge_id] = u;
        es[inner_edge_id] = {v, idx, xdi};
        inner_edge_id++;
        start[inner_edge_id] = v;
        es[inner_edge_id] = {u, xdi, idx};
        inner_edge_id++;
    }
};
```

```

    if(inner_edge_id == 2 * n - 2) { es_build(); }
}
vector<V> build(int root_ = 0) {
    root = root_;
    vector<V> subdp(n);
    subdp[0] = put_vertex(e(), 0);
    outs.resize(n);
    vector<int> geta(n + 1, 0);
    for(int i = 0; i < n; i++) geta[i + 1] = start[i + 1] -
start[i] - 1;
    geta[root + 1]++;
    for(int i = 0; i < n; i++) geta[i + 1] += geta[i];
    auto dfs = [&](auto sfs, int v, int f) -> void {
        E val = e();
        for(int i = start[v]; i < start[v + 1]; i++) {
            if(es[i].to == f) { swap(es[start[v + 1] - 1],
es[i]); }
            if(es[i].to == f) continue;
            sfs(sfs, es[i].to, v);
            E nval = put_edge(subdp[es[i].to], es[i].idx);
            outs[geta[v]++] = nval;
            val = merge(val, nval);
        }
        subdp[v] = put_vertex(val, v);
    };
    dfs(dfs, root, -1);
    return subdp;
}
vector<V> reroot() {
    vector<E> reverse_edge(n);
    reverse_edge[root] = e();
    vector<V> answers(n);
    auto dfs = [&](auto sfs, int v) -> void {
        int le = outs_start(v);
        int ri = outs_start(v + 1);
        int siz = ri - le;
        vector<E> rui(siz + 1);
        rui[siz] = e();
        for(int i = siz - 1; i >= 0; i--) { rui[i] =
merge(outs[le + i], rui[i + 1]); }
        answers[v] = put_vertex(merge(rui[0],
reverse_edge[v]), v);
        E lui = e();
        for(int i = 0; i < siz; i++) {
            V rdp = put_vertex(merge(merge(lui, rui[i + 1]),
reverse_edge[v]), v);
            reverse_edge[es[start[v] + i].to] = put_edge(rdp,
es[start[v] + i].xdi);
            lui = merge(lui, outs[le + i]);
            sfs(sfs, es[start[v] + i].to);
        }
    };
    dfs(dfs, root);
    return answers;
}

private:
int n, root, inner_edge_id;
vector<E> outs;
vector<edge> es;
vector<int> start;
int outs_start(int v) {
    int res = start[v] - v;
    if(root < v) res++;
    return res;
}
void es_build() {
    vector<edge> nes(2 * n - 2);
    vector<int> nstart(n + 2, 0);
    for(int i = 0; i < 2 * n - 2; i++) nstart[start[i] +
2]++;
    for(int i = 0; i < n; i++) nstart[i + 1] += nstart[i];
    for(int i = 0; i < 2 * n - 2; i++) nes[nstart[start[i] +
1]++] = es[i];
    swap(es, nes);
    swap(start, nstart);
}
};

using S = ll;

using T = ll;

```

```

S merge(S a, S b) { return a * b; }
S e() { return 1; }
S put_edge(T v, int i) { return v + 1; }
T put_vertex(S e, int v) { return e; }

```

## lca.hpp

md5: 281c40

```

template<class graph> struct lca {
    const graph& G;
    vector<vector<int>> parent;
    vector<int> dep;
    int log = 1;
    lca(const graph& G, int root = 0) : G(G) { init(root); }
    void init(int root = 0) {
        const int n = G.size();
        dep.assign(n, -1);
        parent.assign(1, vector<int>(n, -1));
        queue<int> que({root});
        dep[root] = 0;
        int max_dep = 0;
        while(!que.empty()) {
            const int pos = que.front();
            que.pop();
            max_dep = max(max_dep, dep[pos]);
            for(const auto& x : G[pos]) {
                if(dep[x] == -1) {
                    dep[x] = dep[pos] + 1;
                    parent[0][x] = pos;
                    que.push(x);
                }
            }
        }
        while((1 << log) <= max_dep) log++;
        parent.resize(log, vector<int>(n, -1));
        for(int k = 0; k < log - 1; k++) {
            for(int v = 0; v < n; v++) {
                if(parent[k][v] < 0) parent[k + 1][v] = -1;
                else parent[k + 1][v] = parent[k][parent[k][v]];
            }
        }
    }
    int query(int u, int v) const {
        if(dep[u] < dep[v]) swap(u, v);
        const int sub = dep[u] - dep[v];
        for(int k = 0; k < log; k++) {
            if(!(sub >> k)) break;
            if(sub >> k & 1) u = parent[k][u];
        }
        if(u == v) return u;
        for(int k = __lg(dep[u]); k >= 0; k--) {
            if(parent[k][u] != parent[k][v]) {
                u = parent[k][u];
                v = parent[k][v];
            }
        }
        return parent[0][u];
    }
    int dist(const int u, const int v) const { return dep[u] +
dep[v] - dep[query(u, v)] * 2; }
    int jump(int u, int v, int d) const {
        const int lc = query(u, v);
        const int l = dep[u] - dep[lc];
        const int r = dep[v] - dep[lc];
        if(d < 0 || d > l + r) return -1;
        if(l < d) {
            d = l + r - d;
            swap(u, v);
        }
        for(int k = 0; k < log; k++) {
            if(!(d >> k)) break;
            if(d >> k & 1) u = parent[k][u];
        }
        return u;
    }
};

```

flow

dinic.hppmd5: fd2103

```
struct Dinic {
    int V; // 頂点数
    vector<vector<vector<ll>>> graph; // グラフ
    vector<int> dis; // 始点からの距離
    vector<int> next; // 次に処理する頂点のメモ
    Dinic(int v) : V(v) { graph.resize(V); }
    void add_edge(int from, int to, ll capacity) {
        graph[from].push_back({to, capacity,
1});
    }
    void bfs(int s) {
        dis.assign(V, -1);
        dis[s] = 0;
        deque<int> pos = {s};
        while(pos.size()) {
            int now = pos[0];
            pos.pop_front();
            for(auto& to : graph[now]) {
                if(dis[to[0]] < 0 and to[1] > 0) {
                    dis[to[0]] = dis[now] + 1;
                    pos.emplace_back(to[0]);
                }
            }
        }
    }
    ll dfs(int v, int t, ll f) {
        if(v == t) return f;
        for(int& i = next[v]; i < graph[v].size(); i++) {
            int to = graph[v][i][0];
            ll& cap = graph[v][i][1];
            int rev = graph[v][i][2];
            if(cap > 0 and dis[v] < dis[to]) {
                ll d = dfs(to, t, min(f, cap));
                if(d > 0) {
                    cap -= d;
                    graph[to][rev][1] += d;
                    return d;
                }
            }
        }
        return 0;
    }
    ll max_flow(int s, int t) {
        ll flow = 0;
        while(1) {
            bfs(s);
            if(dis[t] < 0) return flow;
            next.assign(V, 0);
            ll f;
            while((f = dfs(s, t, INF)) > 0) flow += f;
        }
    }
};
```

mincostflow.hppmd5: e93128

```
struct MinCostFlow {
    int V;
    vector<vector<vector<ll>>> g; // g[from] = {{to, 容量, コス
ト, 逆辺のindex} ... }
    vector<ll> h, dis; // ポテンシャル, 最短距離
    vector<int> prevv, preve; // 直前の頂点, 辺

    MinCostFlow(int v) : V(v), g(v), dis(v), prevv(v), preve(v)
{}

    void add_edge(int u, int v, ll c, ll d) {
        g[u].push_back({v, c, d, (int)g[v].size()});
        g[v].push_back({u, 0, -d, (int)g[u].size() - 1});
    }

    ll min_cost_flow(int s, int t, ll f) {
        ll res = 0;
        h.assign(V, 0);
```

```
using Q = pair<ll, int>;
while(f > 0) {
    priority_queue<Q, vector<Q>, greater<Q>> que;
    dis.assign(V, LLONG_MAX);
    dis[s] = 0;
    que.push({0, s});
    while(que.size()) {
        Q q = que.top();
        int v = q.second;
        que.pop();
        if(dis[v] < q.first) continue;
        for(int i = 0; i < g[v].size(); i++) {
            auto edge = g[v][i];
            int to = edge[0];
            ll cap = edge[1], cost = edge[2];
            if(cap > 0 and dis[to] > dis[v] + cost + h[v] -
h[to]) {
                dis[to] = dis[v] + cost + h[v] - h[to];
                prevv[to] = v;
                preve[to] = i;
                que.push({dis[to], to});
            }
        }
    }
    if(dis[t] == INF) return -1;
    for(int i = 0; i < V; i++) h[i] += dis[i];
    ll d = f;
    for(int i = t; i != s; i = prevv[i]) d = min(d,
g[prevv[i]][preve[i]][1]);
    f -= d;
    res += d * h[t];
    for(int i = t; i != s; i = prevv[i]) {
        auto& edge = g[prevv[i]][preve[i]];
        edge[1] -= d;
        g[i][edge[3]][1] += d;
    }
}
return res;
};
```

燃やす埋める.md

変形前の制約	変形後の制約
$x$ が 0 のとき $z$ 失う	$(x, T, z)$
$x$ が 0 のとき $z$ 得る	無条件で $z$ 得る: $(S, x, z)$
$x$ が 1 のとき $z$ 失う	$(S, x, z)$
$x$ が 1 のとき $z$ 得る	無条件で $z$ 得る: $(x, T, z)$
$x, y, \dots$ がすべて 0 のとき $z$ 得る	無条件で $z$ 得る; $(S, w, z), (w, x, \infty), (w, y, \infty)$
$x, y, \dots$ がすべて 1 のとき $z$ 得る	無条件で $z$ 得る; $(w, T, z), (x, w, \infty), (y, w, \infty)$

string

AhoCorasick.hppmd5: dc1171

```
struct Aho {
    using MP = unordered_map<char, int>;
    vector<MP> to;
    vector<int> cnt, fail;
    Aho() : to(1), cnt(1) {}
    int add(const string& s) {
        int v = 0;
        for(char c : s) {
            if(!to[v].count(c)) {
                to[v][c] = to.size();
                to.push_back(MP());
                cnt.push_back(0);
            }
            v = to[v][c];
        }
        cnt[v]++;
        return v;
    }
};
```

```
void init() {
    fail = vector<int>(to.size(), -1);
    queue<int> q;
    q.push(0);
    while(!q.empty()) {
        int v = q.front();
        q.pop();
        for(auto [c, u] : to[v]) {
            fail[u] = (*this)(fail[v], c);
            cnt[u] += cnt[fail[u]];
            q.push(u);
        }
    }
}

int operator()(int v, char c) const {
    while(v != -1) {
        auto it = to[v].find(c);
        if(it != to[v].end()) return it->second;
        v = fail[v];
    }
    return 0;
}

int operator[](int v) const { return cnt[v]; }
```

### KMP.hpp

md5: 886c63

```
// kmp[i] := max{ l ≤ i | s[:l] == s[(i+1)-l:i+1] }
// abacaba -> 0010123
auto KMP(string s) {
    vector<ll> p(sz(s));
    rep(i, 1, sz(s)) {
        ll g = p[i - 1];
        while(g && s[i] != s[g]) g = p[g - 1];
        p[i] = g + (s[i] == s[g]);
    }
    return p;
}
```

### Manacher.hpp

md5: 5882fb

```
// 各位置での回文半径を求める
// aaabaaa -> 1214121
// 偶数長の回文を含めて直径を知るには, N+1 個の $ を挿入して 1 を引く
// $a$a$a$b$a$a$a$ -> 123432181234321
auto manacher(string s) {
    ll n = sz(s), i = 0, j = 0;
    vector<ll> r(n);
    while(i < n) {
        while(i >= j && i + j < n && s[i - j] == s[i + j]) j++;
        r[i] = j;
        ll k = 1;
        while(i >= k && i + k < n && k + r[i - k] < j) {
            r[i + k] = r[i - k];
            k++;
        }
        i += k, j -= k;
    }
    return r;
}
```

### RollingHash.hpp

md5: adb8d3

```
// using u64 = uint64_t;
const u64 mod = INF;
u64 add(u64 a, u64 b) {
    a += b;
    if(a >= mod) a -= mod;
    return a;
}

u64 mul(u64 a, u64 b) {
    auto c = (__uint128_t)a * b;
    return add(c >> 61, c & mod);
}

random_device rnd;
const u64 r = ((u64)rnd() << 32 | rnd()) % mod;
struct RH {
    ll n;
    vector<u64> hs, pw;
    RH(string s) : n(sz(s)), hs(n + 1), pw(n + 1, 1) {
        rep(i, 0, n) {
```

```
            pw[i + 1] = mul(pw[i], r);
            hs[i + 1] = add(mul(hs[i], r), s[i]);
        }
    }
    u64 get(ll l, ll r) const { return add(hs[r], mod -
mul(hs[l], pw[r - l])); }
};
```

### SuffixArray.hpp

md5: 1d70ce

```
// returns pair{sa, lcp}
// sa 長さ n : s[sa[0]:] < s[sa[1]:] < ... < s[sa[n-1]:]
// lcp 長さ n-1 : lcp[i] = LCP(s[sa[i]:], s[sa[i+1]:])
auto SA(string s) {
    ll n = sz(s) + 1, lim = 256;
    // assert(lim > ranges::max(s));
    vector<ll> sa(n), lcp(n), x(all(s) + 1), y(n), ws(max(n,
lim)), rk(n);
    iota(all(sa), 0);
    for(ll j = 0, p = 0; p < n; j = max(1LL, j * 2), lim = p) {
        p = j;
        iota(all(y), n - j);
        rep(i, 0, n) if(sa[i] >= j) y[p++] = sa[i] - j;
        fill(all(ws), 0);
        rep(i, 0, n) ws[x[i]]++;
        rep(i, 1, lim) ws[i] += ws[i - 1];
        for(ll i = n; i--;) sa[--ws[x[y[i]]]] = y[i];
        swap(x, y);
        p = 1;
        x[sa[0]] = 0;
        rep(i, 1, n) {
            ll a = sa[i - 1], b = sa[i];
            x[b] = (y[a] == y[b] && y[a + j] == y[b + j]) ? p - 1
: p++;
        }
    }
    rep(i, 1, n) rk[sa[i]] = i;
    for(ll i = 0, k = 0; i < n - 1; lcp[rk[i++]] = k) {
        if(k) k--;
        while(s[i + k] == s[sa[rk[i] - 1] + k]) k++;
    }
    sa.erase(begin(sa));
    lcp.erase(begin(lcp));
    return pair{sa, lcp};
}
```

### Trie.hpp

md5: 13af70

```
struct Trie {
    static constexpr int C_SIZE = 26; // C_SIZE : 文字の種類数
    static constexpr int C_BEGIN = 'a'; // C_BEGIN : 開始文字
    static constexpr int ROOT = 0;
    struct Node {
        array<int, C_SIZE> to = {}; // 子ノードの番号, 存在しなければ-1
        vector<int> ids; // そのノードが終端である文字列のIDリスト
        Node() { to.fill(-1); }
    };
    vector<Node> nodes;
    int cnt = 0; // 追加した文字列の個数
    Trie() : nodes(1) {}
    // nodes[idx]から文字cで遷移したときの頂点のindex
    int next(int idx, char c) { return nodes[idx].to[c - C_BEGIN]; }
    // 文字列の追加
    int insert(const string& s) {
        int now = ROOT;
        for(char c : s) {
            int k = c - C_BEGIN;
            if(nodes[now].to[k] == -1) {
                nodes[now].to[k] = nodes.size();
                nodes.push_back(Node());
            }
            now = nodes[now].to[k];
        }
        nodes[now].ids.push_back(cnt++);
        return now;
    }
    // 文字列に対応するnodeのindexを検索, 存在しなければ-1
```

```
int find(const string& s) {
    int now = ROOT;
    for(char c : s) {
        now = next(now, c);
        if(now == -1) return -1;
    }
    return now;
}
};
```

Zalgorithm.hpp

md5: b20b04

```
// Z[i] := LCP(s, s[i:])
// abacaba -> 7010301
auto Z(string s) {
    ll n = sz(s), l = -1, r = -1;
    vector<ll> z(n, n);
    rep(i, 1, n) {
        ll& x = z[i] = i < r ? min(r - i, z[i - l]) : 0;
        while(i + x < n && s[i + x] == s[x]) x++;
        if(i + x > r) l = i, r = i + x;
    }
    return z;
}
```

algorithm

mo.hpp

md5: 934d7d

```
struct Mo {
    int n;
    vector<pair<int, int> > lr;

    explicit Mo(int n) : n(n) {}

    void add(int l, int r) { /* [l, r) */
        lr.emplace_back(l, r);
    }

    template<typename AL, typename AR, typename EL, typename ER,
    typename O>
    void build(const AL& add_left, const AR& add_right, const
    EL& erase_left, const ER& erase_right, const O& out) {
        int q = (int)lr.size();
        int bs = n / min<int>(n, sqrt((double)q));
        vector<int> ord(q);
        iota(begin(ord), end(ord), 0);
        sort(begin(ord), end(ord), [&](int a, int b) {
            int ablock = lr[a].first / bs, bblock = lr[b].first /
bs;
            if(ablock != bblock) return ablock < bblock;
            return (ablock & 1) ? lr[a].second > lr[b].second :
lr[a].second < lr[b].second;
        });
        int l = 0, r = 0;
        for(auto idx : ord) {
            while(l > lr[idx].first) add_left(--l);
            while(r < lr[idx].second) add_right(r++);
            while(l < lr[idx].first) erase_left(l++);
            while(r > lr[idx].second) erase_right(--r);
            out(idx);
        }
    }

    template<typename A, typename E, typename O> void
    build(const A& add, const E& erase, const O& out) {
        build(add, add, erase, erase, out);
    }
};

int main() {
    int N;
    cin >> N;
    vector<int> A(N);
    for(auto& a : A) cin >> a;
    int Q;
    cin >> Q;
    Mo mo(N);
    for(int i = 0; i < Q; i++) {
        int a, b;
        cin >> a >> b;
```

```
        mo.add(a - 1, b);
    }
    vector<int> cnt(1000001), ans(Q);
    int sum = 0;
    auto add = [&](int i) {
        if(cnt[A[i]]++ == 0) ++sum;
    };
    auto erase = [&](int i) {
        if(--cnt[A[i]] == 0) --sum;
    };
    auto out = [&](int q) { ans[q] = sum; };
    mo.build(add, erase, out);
    for(auto& p : ans) cout << p << "\n";
}
```

geometry

geometry.hpp

md5: f4e0fc

```
/*
前提
- 点(位置ベクトル)を複素数型で扱う
- 実軸(real)をx軸、虚軸(imag)をy軸として見る
- 比較するときは、計算誤差を意識して EPS で判定 (equal関数)
*/

namespace geometry {
using D = long double;
using Point = std::complex<D>;
using Polygon = vector<Point>;
const D EPS = 1e-8;
const D PI = M_PI;

// 入出力ストリーム
istream& operator>>(istream& is, Point& p) {
    D a, b;
    is >> a >> b;
    p = Point(a, b);
    return is;
}

ostream& operator<<(ostream& os, Point& p) { return os << fixed
<< setprecision(20) << p.real() << ' ' << p.imag(); }

// d 倍する
Point operator*(Point p, D d) { return Point(p.real() * d,
p.imag() * d); }

// 偏角 (0 <= θ < 2π)
D argument(Point p) {
    D res = arg(p);
    if(res < 0.0) res += 2.0 * PI; // [-π, π] -> [0, 2π]
    return res;
}

// 等しいかどうか (誤差で判定)
inline bool equal(D a, D b) { return fabs(a - b) < EPS; }

// 単位ベクトル
Point unit_vector(Point a) { return a / abs(a); };

// 法線ベクトル (逆向きがよければ (0, -1) をかける)
Point normal_vector(Point a, D dir = 1) { return a * Point(0,
dir); }

// 内積 : a・b = |a||b|cosθ
D dot(Point a, Point b) { return (a.real() * b.real() +
a.imag() * b.imag()); }

// 外積 : a×b = |a||b|sinθ (外積の大きさではないか?)
D cross(Point a, Point b) { return (a.real() * b.imag() -
a.imag() * b.real()); }

// 反時計回りに theta 回転
Point rotate(Point a, D theta) {
    D c = cos(theta), s = sin(theta);
    return Point(c * a.real() - s * a.imag(), s * a.real() + c *
a.imag());
}
```

```

// 直線
struct Line {
    Point a, b;
    Line() = default;
    Line(Point a_, Point b_) : a(a_), b(b_) { assert(a_ != b_); }
};

// Ax+By=C
Line(D A, D B, D C) {
    if(equal(A, 0)) {
        a = Point(0, C / B), b = Point(1, C / B);
    } else if(equal(B, 0)) {
        b = Point(C / A, 0), a = Point(C / A, 1);
    } else {
        a = Point(0, C / B), b = Point(C / A, 0);
    }
}

// 線分 (Line と同じ)
struct Segment : Line {
    Segment() = default;
    Segment(Point a_, Point b_) : Line(a_, b_){};
};

// 円 (中心と半径)
struct Circle {
    Point p;
    D r;
    Circle(Point p_, D r_) : p(p_), r(r_) {}
};

// 射影: 直線 (線分) に 点p から引いた垂線の足を求める
Point projection(Line l, Point p) {
    D t = dot(p - l.a, l.a - l.b) / norm(l.a - l.b);
    return l.a + (l.a - l.b) * t;
}

Point projection(Segment l, Point p) {
    D t = dot(p - l.a, l.a - l.b) / norm(l.a - l.b);
    return l.a + (l.a - l.b) * t;
}

// 反射: 直線を対象軸として 点p と線対称の位置にある点を求める
Point reflection(Line l, Point p) { return p + (projection(l, p) - p) * 2.0; }

// 3点 a, b, c の位置関係
int ccw(Point a, Point b, Point c) {
    b -= a, c -= a;
    // 点 a, b, c が
    if(cross(b, c) > EPS) return 1; // 反時計回りのとき
    if(cross(b, c) < -EPS) return -1; // 時計回りのとき

    // 同一直線上にある場合
    if(dot(b, c) < 0) return 2; // c, a, b の順
    if(norm(b) < norm(c)) return -2; // a, b, c の順
    return 0; // a, c, b の順
}

// 垂直 (内積 == 0)
bool is_vertical(Line a, Line b) { return equal(dot(a.b - a.a, b.b - b.a), 0); }

// 平行 (外積 == 0)
bool is_parallel(Line a, Line b) { return equal(cross(a.b - a.a, b.b - b.a), 0); }

// 線分の交差判定 (線分 s に対して, 線分 t の端点が反対側にあればよい)
bool is_intersect(Segment s, Segment t) {
    return (ccw(s.a, s.b, t.a) * ccw(s.a, s.b, t.b) <= 0) &&
        (ccw(t.a, t.b, s.a) * ccw(t.a, t.b, s.b) <= 0);
}

// 交点 (交差する前提)
Point cross_point(Line s, Line t) {
    D d1 = cross(s.b - s.a, t.b - t.a);
    D d2 = cross(s.b - s.a, s.b - t.a);
    // s, t が一致する場合 (適当な1点を返す)
    if(equal(abs(d1), 0) && equal(abs(d2), 0)) return t.a;

    return t.a + (t.b - t.a) * (d2 / d1);
}

```

```

}

Point cross_point(Segment s, Segment t) {
    assert(is_intersect(s, t)); // 交差する前提
    return cross_point(Line(s), Line(t));
}

// 点間の距離
D dist(Point a, Point b) { return abs(a - b); }

// 点と直線の距離 (垂線の足との距離)
D dist_line_point(Line l, Point p) { return abs(p - projection(l, p)); }

// 線分と点の距離 (点p から線分のどこかへの最短距離)
D dist_segment_point(Segment l, Point p) {
    if(dot(l.b - l.a, p - l.a) < EPS) return abs(p - l.a);
    if(dot(l.a - l.b, p - l.b) < EPS) return abs(p - l.b);
    return abs(cross(l.b - l.a, p - l.a)) / abs(l.b - l.a);
}

// 線分と線分の距離
D dist_segment_segment(Segment s, Segment t) {
    if(is_intersect(s, t)) return 0.0;
    D res = min({
        dist_segment_point(s, t.a),
        dist_segment_point(s, t.b),
        dist_segment_point(t, s.a),
        dist_segment_point(t, s.b),
    });
    return res;
}

// 2つの円の交点
pair<Point, Point> crosspoint(const Circle& c1, const Circle& c2) {
    D d = abs(c1.p - c2.p);
    D a = acos((c1.r * c1.r + d * d - c2.r * c2.r) / (2 * c1.r * d));
    D t = atan2(c2.p.imag() - c1.p.imag(), c2.p.real() - c1.p.real());
    Point p1 = c1.p + Point(cos(t + a) * c1.r, sin(t + a) * c1.r);
    Point p2 = c1.p + Point(cos(t - a) * c1.r, sin(t - a) * c1.r);
    return {p1, p2};
}

ll cross_cht(Point o, Point a, Point b) {
    return (a.real() - o.real()) * (b.imag() - o.imag()) -
        (a.imag() - o.imag()) * (b.real() - o.real());
}

// 凸包
Polygon convex_hull(Polygon ps) {
    int n = ps.size(), k = 0;
    if(n <= 2) return ps;
    sort(ps.begin(), ps.end(),
        [](const Point& a, const Point& b) { return real(a) != real(b) ? real(a) < real(b) : imag(a) < imag(b); });
    Polygon res;
    for(auto p : ps) {
        while((int)res.size() >= 2 && cross_cht(res[k - 1], res[k - 2], p) >= 0) {
            res.pop_back();
            k--;
        }
        res.push_back(p);
        k++;
    }
    int t = res.size();
    rrep(i, n - 2, 0) {
        while((int)res.size() > t && cross_cht(res[k - 1], res[k - 2], ps[i]) >= 0) {
            res.pop_back();
            k--;
        }
        res.push_back(ps[i]);
        k++;
    }
    return res;
}

```

```
}; // namespace geometry
using namespace geometry;
```

memo

Primes.md

素数の個数

$n$	$10^2$	$10^3$	$10^4$	$10^5$	$10^6$	$10^7$	$10^8$	$10^9$	$10^{10}$
$\pi(n)$	25	168	1229	9592	78498	664579	5.76e+6	5.08e+7	4.55e+8

高度合成数

$\leq n$	$10^3$	$10^4$	$10^5$	$10^6$	$10^7$	$10^8$	$10^9$
$x$	840	7560	83160	720720	8648640	73513440	735134400

$\leq n$	$10^3$	$10^4$	$10^5$	$10^6$	$10^7$	$10^8$	$10^9$		
$d^0(x)$	32	64	128	240	448	768	1344		
$\leq n$	$10^{10}$	$10^{11}$	$10^{12}$	$10^{13}$	$10^{14}$	$10^{15}$	$10^{16}$	$10^{17}$	$10^{18}$
$d^0(x)$	2304	4032	6720	10752	17280	26880	41472	64512	103680

素数階乗

$n$	2	3	5	7	11	13	17	19	23	29
$n\#$	2	6	30	210	2310	30030	510510	9.70e+6	2.23e+8	6.47e+9

階乗

4!	5!	6!	7!	8!	9!	10!	11!	12!	13!
24	120	720	5040	40320	362880	3.63e+6	3.99e+7	4.79e+8	6.23e+9