Contents

1. Contest

1.1. template.h

```cpp
#include <bits/stdc++.h>
#include <ext/pb_ds/assoc_container.hpp>
//#pragma GCC target("bmi,bmi2,lzcnt,popcnt")
//#pragma GCC optimize("O2,unroll-loops")
//#pragma GCC target("avx2")

//#pragma GCC optimize("O2")
//#pragma GCC optimize("Ofast")
//#pragma GCC target("avx,avx2,fma")
using namespace std;
using namespace __gnu_pbds;
typedef tree<int, null_type, less<int>,
rb_tree_tag, tree_order_statistics_node_update>
o_set;
// order_of_key (val): returns the no. of values
less than val
// find_by_order (k): returns the kth largest
element.(0-based)
template <typename T>
using minHeap = priority_queue<T, vector<T>,
greater<T>>;
template <typename T>
using maxHeap = priority_queue<T>;
#define int long long
#define all(s) s.begin(), s.end()
#define sz(s) (int)s.size()
using longer = __int128_t;
typedef vector<int> vi;
typedef pair<int, int> pii;
const int INF = numeric_limits<int>::max();
const int M = 1e9 + 7;
void solve() {}
int32_t main() {
    ios_base::sync_with_stdio(0);
    cin.tie(NULL);
    cout.tie(NULL);
    int tt; cin >> tt;
    while (tt--) solve();
}
template <const i32 mod>
struct mint {
    constexpr mint(i32 x = 0) : val(x % mod + (x <
0) * mod) {}
    mint &operator+=(const mint &b) {
        val += b.val;
        val -= mod * (val >= mod);
        return *this;
    }
    mint &operator-=(const mint &b) {
```

```
        val -= b.val;
        val += mod * (val < 0);
        return *this;
    }
    mint &operator*=(const mint &b) {
        val = 1ll * val * b.val % mod;
        return *this;
    }
    mint &operator/=(const mint &b) { return *this
*= b.inv(); }
    mint inv() const {
        i32 x = 1, y = 0, t;
        for (i32 a = val, b = mod; b; swap(a, b),
swap(x, y))
            t = a / b, a -= t * b, x -= t * y;
        return mint(x);
    }
    mint pow(int b) const {
        mint a = *this, res(1);
        for (; b; a *= a, b /= 2)
            if (b & 1) res *= a;
        return res;
    }
    friend mint operator+(const mint &a, const mint
&b) { return mint(a) += b; }
    friend mint operator-(const mint &a, const mint
&b) { return mint(a) -= b; }
    friend mint operator*(const mint &a, const mint
&b) { return mint(a) *= b; }
    friend mint operator/(const mint &a, const mint
&b) { return mint(a) /= b; }
    friend bool operator==(const mint &a, const
mint &b) { return a.val == b.val; }
    friend bool operator!=(const mint &a, const
mint &b) { return a.val != b.val; }
    friend bool operator<(const mint &a, const mint
&b) { return a.val < b.val; }
    friend ostream &operator<<(ostream &os, const
mint &a) { return os << a.val; }
    i32 val;
};
```

2. Data Structures

2.1. SegTree.h

```
template <typename T, typename F>
struct SegTree {
  int n, off, ct;
  vector<T> t;
  const T id;
  F f;
  SegTree(const vector<T>& a, T _id, F _f)
    : n(sz(a)), off(1 << 32 - __builtin_clz(n)),
ct(n ^ off >> 1), t(2 * n), id(_id), f(_f) {
    for (int i = 0; i < 2 * ct; i++) t[off + i] =
a[i];
    for (int i = 2 * ct; i < n; i++) t[i + off - n]
= a[i];
    for (int i = n - 1; i >= 1; i--) t[i] = f(t[2 *
i], t[2 * i + 1]);
  }
```

```
  int i2leaf(int i) { return i + off - (i < 2 *
ct ? 0 : n); }
  int leaf2i(int l) { return l - off + (l < off ?
n : 0); }
  T query(int l, int r) {
    l = (l < 2 * ct) ? (l + off) : 2 * (l + off -
n);
    r = (r < 2 * ct) ? (r + off) : 2 * (r + off -
n);
    r += (r >= 2 * n);
    T resl(id), resr(id);
    for (; l <= r; l >>= 1, r >>= 1) {
        if (l == r) {
            resl = f(resl, t[l]);
            break;
        }
        if (l & 1) resl = f(resl, t[l++]);
        if (!(r & 1)) resr = f(t[r--], resr);
    }
    return f(resl, resr);
  }
  void update(int v, T value) {
    for (t[v = i2leaf(v)] = value; v >>= 1;)
        t[v] = f(t[2 * v], t[2 * v + 1]);
  }
  int lower_bound(int k) {
    if (t[1] < k) return n;
    T rem = id;
    int v = 1;
    while (v < n) {
        T resl = f(rem, t[2 * v]);
        if (resl >= k) {
            v = 2 * v;
        } else {
            rem = resl;
            v = 2 * v + 1;
        }
    }
    return leaf2i(v);
  }
};
```

2.2. LazySegTree.h

```
template<typename T, typename U> struct
seg_tree_lazy {
    int S, H;
    T zero;
    vector<T> value;
    U noop;
    vector<bool> dirty;
    vector<U> prop;
    seg_tree_lazy(int _S, T _zero = T(), U _noop =
U()) {
        zero = _zero, noop = _noop;
        for (S = 1, H = 1; S < _S; ) S *= 2, H++;
        value.resize(2*S, zero);
        dirty.resize(2*S, false);
        prop.resize(2*S, noop);
    }
    void set_leaves(vector<T> &leaves) {
```

```
        copy(leaves.begin(), leaves.end(),
value.begin() + S);
        for (int i = S - 1; i > 0; i--)
            value[i] = value[2 * i] + value[2 * i +
1];
    }
    void apply(int i, U &update) {
        value[i] = update(value[i]);
        if(i < S) {
            prop[i] = prop[i] + update;
            dirty[i] = true;
        }
    }
    void rebuild(int i) {
        for (int l = i/2; l; l /= 2) {
            T combined = value[2*l] + value[2*l+1];
            value[l] = prop[l](combined);
        }
    }
    void propagate(int i) {
        for (int h = H; h > 0; h--) {
            int l = i >> h;
            if (dirty[l]) {
                apply(2*l, prop[l]);
                apply(2*l+1, prop[l]);

                prop[l] = noop;
                dirty[l] = false;
            }
        }
    }
    void upd(int i, int j, U update) {
        i += S, j += S;
        propagate(i), propagate(j);
        for (int l = i, r = j; l <= r; l /= 2, r /=
2) {
            if((l&1) == 1) apply(l++, update);
            if((r&1) == 0) apply(r--, update);
        }
        rebuild(i), rebuild(j);
    }
    T query(int i, int j){
        i += S, j += S;
        propagate(i), propagate(j);
        T res_left = zero, res_right = zero;
        for(; i <= j; i /= 2, j /= 2){
            if((i&1) == 1) res_left = res_left +
value[i++];
            if((j&1) == 0) res_right = value[j--] +
res_right;
        }
        return res_left + res_right;
    }
};
struct node {
    int sum, width;
    node operator+(const node &n) {
        // Change 1
        return { sum + n.sum, width + n.width };
    }
```

```
};
struct update {
    bool type; // 0 for add, 1 for reset
    int value;
    node operator()(const node &n) { // apply
update on n
        // Change 2
        if (type) return { n.width * value,
n.width };
        else return { n.sum + n.width * value,
n.width };
    }
    update operator+(const update &u) { // u is the
recent update, *this is the older update
        // Change 3
        if (u.type) return u;
        return { type, value + u.value };
    }
};
```

2.3. RMQ.h

```
template<class T>
struct RMQ {
    vector<vector<T>> jmp;
    RMQ(const vector<T>& V) : jmp(1, V) {
        for (int pw = 1, k = 1; pw * 2 ⩽ sz(V); pw
*= 2, ++k) {
            jmp.emplace_back(sz(V) - pw * 2 + 1);
            for (int j = 0; j < sz(jmp[k]); j++)
                jmp[k][j] = min(jmp[k - 1][j],
jmp[k - 1][j + pw]);
        }
    }
    T query(int a, int b) {
        assert(a ⩽ b); // tie(a, b) = minimax(a,
b)
        int dep = 63 - __builtin_clzll(b-a+1);
        return min(jmp[dep][a], jmp[dep][b - (1 <<
dep) + 1]);
    }
};
```

2.4. Fenwick.h

```
template <typename T>
struct Fenwick {
    vector<T> bit;
    vector<T>& original;
    Fenwick(vector<T>& _arr) : bit(_arr.size(),
0LL), original(_arr) {
        int n = sz(_arr);
        for (int i = 0; i < n; i++) {
            bit[i] = bit[i] + _arr[i];
            if ((i | (i + 1)) < n) bit[(i | (i +
1))] = bit[(i | (i + 1))] + bit[i];
        }
    }
    // returns smallest index i, st. sum[0..i] ⩾
x, returns -1 if no such i exists
    // returns n if x ⩾ sum of array
    // ASSUMES NON NEGATIVE ENTRIES IN TREE
```

```
    int lower_bound(int x) {
        if (x < 0) return -1;
        if (x == 0) return 0;
        int pos = 0;
        for (int pw = 1LL << 20; pw; pw >>= 1)
            if (pw + pos <= sz(bit) and bit[pos +
pw - 1] < x)
                pos += pw, x -= bit[pos - 1];
        return pos;
    }
    T query(int r) {
        assert(r < sz(bit));
        int ret = 0;
        for (r++; r > 0; r &= r - 1) ret += bit[r -
1];
        return ret;
    }
    T query(int l, int r) {
        T ret = query(r);
        if (l != 0) ret -= query(l - 1);
        return ret;
    }
    void update(int i, int x) {
        int n = bit.size();
        T diff = x - original[i];
        original[i] = x;
        for (; i < n; i = i | i + 1) bit[i] +=
diff;
    }
};
```

2.5. cht.h

```
using i64 = int64_t;

struct Line {
    mutable i64 m, c, p;
    bool operator<(const Line& o) const { return m
< o.m; }
    bool operator<(i64 x) const { return p < x; }
};

struct LineContainer : multiset<Line, less<>> {
    // (for doubles, use inf = 1/.0, div(a,b) = a/
b)
    static const i64 inf = LONG_LONG_MAX;
    i64 div(i64 a, i64 b) {  // floored division
        return a / b - ((a ^ b) < 0 && a % b);
    }
    bool isect(iterator x, iterator y) {
        if (y == end()) return x->p = inf, 0;
        if (x->m == y->m)
            x->p = x->c > y->c ? inf : -inf;
        else
            x->p = div(y->c - x->c, x->m - y->m);
        return x->p >= y->p;
    }
    void add(i64 m, i64 c) {
        auto z = insert({m, c, 0}), y = z++, x = y;
        while (isect(y, z)) z = erase(z);
        if (x != begin() && isect(--x, y)) isect(x,
y = erase(y));
```

```
        while ((y = x) != begin() && (--x)->p >= y->p)
            isect(x, erase(y));
    }
    i64 query(i64 x) {
        assert(!empty());
        auto l = *lower_bound(x);
        return l.m * x + l.c;
    }
};
```

2.6. DSU.h

```
struct DSU {
    int n;
    vector<int> parent;
    vector<int> size;
    DSU(int _n) : n(_n), parent(n), size(n, 1) { iota(parent.begin(), parent.end(), 0); }
    int find_set(int x) {
        if (parent[x] == x) return x;
        return parent[x] = find_set(parent[x]);
    }
    int getSize(int x) { return size[find_set(x)]; }  // returns size of component of x
    void union_sets(int x, int y) {
        x = find_set(x);
        y = find_set(y);
        if (x == y) return;
        if (size[x] > size[y]) {
            parent[y] = x;
            size[x] += size[y];
        } else {
            parent[x] = y;
            size[y] += size[x];
        }
    }
};
```

2.7. Fenwick2D.h

```
const int mxn = 1000;
int grid[mxn + 1][mxn + 1];
int bit[mxn + 1][mxn + 1];
void update(int row, int col, int d) {
  grid[row][col] += d;
  for (int i = row; i <= mxn; i += (i & -i))
    for (int j = col; j <= mxn; j += (j & -j))
      bit[i][j] += d;
}
int sum(int row, int col) {
  // calculates sum from [1,1] till [row,col]
  int res = 0;
  for (int i = row; i > 0; i -= (i & -i))
    for (int j = col; j > 0; j -= (j & -j))
      res += bit[i][j];
  return res;
}
```

2.8. Mos.h

```
int BLOCK = DO_NOT_FORGET_TO_CHANGE_THIS;
struct Query {
```

```
  int l, r, id;
  Query(int _l, int _r, int _id) : l(_l), r(_r),
id(_id) {}
  bool operator<(Query &o) {
    int mblock = l / BLOCK, oblock = o.l / BLOCK;
    return (mblock < oblock) or
           (mblock == oblock and mblock % 2 == 0
and r < o.r) or
           (mblock == oblock and mblock % 2 == 1
and r > o.r);
  };
};
// Solve
void solve() {
  vector<Query> queries;
  queries.reserve(q);
  for (int i = 0; i < q; i++) {
    int l, r; cin >> l >> r;
    l--, r--;
    queries.emplace_back(l, r, i);
  }
  sort(all(queries));
  int ans = 0;
  auto add = [&](int v) {};
  auto rem = [&](int v) {};
  vector<int> out(q);  // Change out type if
necessary
  int cur_l = 0, cur_r = -1;
  for (auto &[l, r, id] : queries) {
    while (cur_l > l) add(--cur_l);
    while (cur_l < l) rem(cur_l++);
    while (cur_r < r) add(++cur_r);
    while (cur_r > r) rem(cur_r--);
    out[id] = ans;
  }
}
```

2.9. Persistent.h

```
const int N = 5e5 + 10, LOGN = 18;
int L[N * LOGN], R[N * LOGN], ST[N * LOGN];
int nodeid = 0;
// usage newrootId = update(i, 0, n - 1, val,
oldrootId)
// [update index i to val]
int update(int pos, int l, int r, int val, int id)
{
    if (pos < l or pos > r) return id;
    int ID = ++nodeid, m = (l + r) / 2;
    if (l == r) return (ST[ID] = val, ID);
    L[ID] = update(pos, l, m, val, L[id]);
    R[ID] = update(pos, m + 1, r, val, R[id]);
    return (ST[ID] = ST[L[ID]] + ST[R[ID]], ID);
}
// usage query(l, r, 0, n - 1, rootId)
int query(int ql, int qr, int l, int r, int id) {
    if (ql > r or qr < l) return 0;
    if (ql <= l and r <= qr) return ST[id];
    int m = (l + r) / 2;
    return (query(ql, qr, l, m, L[id])) + query(ql,
qr, m + 1, r, R[id]);
```

```
}
// searches for upper bound of x, call as
descent(0, n - 1, x, rootId)
int descent(int l, int r, int x, int id) {
    if (l == r) return l;
    int m = (l + r) / 2;
    int leftCount = ST[L[id]];
    if (leftCount ⩽ x) {
        // is in right half
        return descent(m + 1, r, x - leftCount,
R[id]);
    } else {
        // is in left half
        return descent(l, m, x, L[id]);
    }
}
```

2.10. Treap.h

```
/*A short self-balancing tree. It acts as a
sequential container with log-time splits/joins,
and
is easy to augment with additional data.
Time: $O(\log N)$*/

struct Node {
  Node *l = 0, *r = 0;
  int val, y, c = 1;
  Node(int val) : val(val), y(rand()) {}
  void recalc();
};
int cnt(Node* n) { return n ? n->c : 0; }
void Node::recalc() { c = cnt(l) + cnt(r) + 1; }

template<class F> void each(Node* n, F f) {
  if (n) { each(n->l, f); f(n->val); each(n->r,
f); }
}

pair<Node*, Node*> split(Node* n, int k) {
  if (!n) return {};
  if (cnt(n->l) ⩾ k) { // "n->val ⩾ k" for
lower_bound(k)
    auto pa = split(n->l, k);
    n->l = pa.second;
    n->recalc();
    return {pa.first, n};
  } else {
    auto pa = split(n->r, k - cnt(n->l) - 1); //
and just "k"
    n->r = pa.first;
    n->recalc();
    return {n, pa.second};
  }
}

Node* merge(Node* l, Node* r) {
  if (!l) return r;
  if (!r) return l;
  if (l->y > r->y) {
```

```
    l->r = merge(l->r, r);
    l->recalc();
    return l;
  } else {
    r->l = merge(l, r->l);
    r->recalc();
    return r;
  }
}

Node* ins(Node* t, Node* n, int pos) {
  auto [l,r] = split(t, pos);
  return merge(merge(l, n), r);
}

// Example application: move the range [l, r) to
index k
void move(Node*& t, int l, int r, int k) {
  Node *a, *b, *c;
  tie(a,b) = split(t, l); tie(b,c) = split(b, r -
l);
  if (k <= l) t = merge(ins(a, b, k), c);
  else t = merge(a, ins(c, b, k - r));
}
```

3. Graph

3.1. SCC.h

```
struct SCC {
    int n;
    vi val, cc, z;
    vvi comps;
    SCC(vvi& adj) : n(sz(adj)), val(n), cc(n, -1) {
        int timer = 0;
        function<int(int)> dfs = [&] (int x) {
            int low = val[x] = ++timer, b;
z.push_back(x);
            for (auto y : adj[x]) if (cc[y] < 0)
                low = min(low, val[y] ?: dfs(y));

            if (low == val[x]) {
                comps.push_back(vi());
                do {
                    b = z.back(); z.pop_back();
                    comps.back().push_back(b);
                    cc[b] = sz(comps) - 1;
                } while (x != b);
            }
            return val[x] = low;
        };
        for (int i = 0; i < n; i++) if (cc[i] < 0)
dfs(i);
    }
    int operator[](int i) { return cc[i]; }
    int size(int i) { return sz(comps[cc[i]]); }
};
```

3.2. LCA.h

```
struct LCA {
  int T = 0;
  vi st, path, ret;
```

```
  vi en, d;
  RMQ<int> rmq;
  LCA(vector<vi>& C) : st(sz(C)), en(sz(C)),
d(sz(C)), rmq((dfs(C, 0, -1), ret)) {}
  void dfs(vvi& adj, int v, int par) {
    st[v] = T++;
    for (auto to : adj[v])
      if (to != par) {
        path.pb(v), ret.pb(st[v]);
        d[to] = d[v] + 1;
        dfs(adj, to, v);
      }
    en[v] = T - 1;
  }
  bool anc(int p, int c) { return st[p] <= st[c]
and en[p] >= en[c]; }
  int lca(int a, int b) {
    if (a == b) return a;
    tie(a, b) = minmax(st[a], st[b]);
    return path[rmq.query(a, b - 1)];
  }
  int dist(int a, int b) { return d[a] + d[b] - 2 *
d[lca(a, b)]; }
};
```

3.3. 2sat.h

```
/*
ts.either(x, y);
ts.either(~x, ~y); these two do x xor y
ts.setValue(x, x); assert x is true

use ~x to denote not x

call ts.solve() to run the solver, returns if a
solution exists
if exists: ts.values[i] contains the assignments
*/

struct TwoSat {
  int N;
  vector<vi> gr;
  vi 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++;
  }

  void either(int f, int j) {
      f = max(2 * f, -1 - 2 * f);
      j = max(2 * j, -1 - 2 * j);
      gr[f].push_back(j ^ 1);
      gr[j].push_back(f ^ 1);
  }
  void setValue(int x) { either(x, x); }
```

```
void atMostOne(const vi& li) {  // (optional)
    if (sz(li) <= 1) return;
    int cur = ~li[0];
    for (int i = 2; i < sz(li); i++) {
        int next = addVar();
        either(cur, ~li[i]);
        either(cur, next);
        either(~li[i], next);
        cur = ~next;
    }
    either(cur, ~li[1]);
}

vi 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;
      for (int i = 0; i < 2 * N; i++)
          if (!comp[i]) dfs(i);
      for (int i = 0; i < N; i++)
          if (comp[2 * i] == comp[2 * i + 1])
return 0;
      return 1;
  }
};
```

3.4. Dinic.h

```
// Flow algorithm with complexity $O(VE\log U)$
where $U = \max |\text{cap}|$.
// $O(\min(E^{1/2}, V^{2/3})E)$ if $U = 1$;
$O(\sqrt{V}E)$ for bipartite matching.
using ll = long long;
#define rep(i, j, k) for (int i = j; i < k; i++)
struct Dinic {
  struct Edge {
    int to, rev;
    ll c, oc;
    ll flow() { return max(oc - c, 0LL); } // if
you need flows
  };
  vi lvl, ptr, q;
  vector<vector<Edge>> adj;
```

```
  Dinic(int n) : lvl(n), ptr(n), q(n), adj(n) {}
  void addEdge(int a, int b, ll c, ll rcap = 0) {
    adj[a].push_back({b, sz(adj[b]), c, c});
    adj[b].push_back({a, sz(adj[a]) - 1, rcap,
rcap});
  }
  ll dfs(int v, int t, ll f) {
    if (v == t || !f) return f;
    for (int& i = ptr[v]; i < sz(adj[v]); i++) {
      Edge& e = adj[v][i];
      if (lvl[e.to] == lvl[v] + 1)
        if (ll p = dfs(e.to, t, min(f, e.c))) {
          e.c -= p, adj[e.to][e.rev].c += p;
          return p;
        }
    }
    return 0;
  }
  ll calc(int s, int t) {
    ll flow = 0; q[0] = s;
    rep(L,0,31) do { // 'int L=30' maybe faster for
random data
      lvl = ptr = vi(sz(q));
      int qi = 0, qe = lvl[s] = 1;
      while (qi < qe && !lvl[t]) {
        int v = q[qi++];
        for (Edge e : adj[v])
          if (!lvl[e.to] && e.c >> (30 - L))
            q[qe++] = e.to, lvl[e.to] = lvl[v] + 1;
      }
      while (ll p = dfs(s, t, LLONG_MAX)) flow +=
p;
    } while (lvl[t]);
    return flow;
  }
  bool leftOfMinCut(int a) { return lvl[a] != 0; }
};
```

3.5. HLD.h

```
struct HLD {
  int n, timer = 0;
  vi top, tin, p, sub;
  HLD(vvi &adj) : n(sz(adj)), top(n), tin(n), p(n,
-1), sub(n, 1) {
    vi ord(n + 1);
    for (int i = 0, t = 0, v = ord[i]; i < n; v =
ord[++i])
      for (auto &to : adj[v])
        if (to != p[v]) p[to] = v, ord[++t] = to;
    for (int i = n - 1, v = ord[i]; i > 0; v =
ord[--i]) sub[p[v]] += sub[v];
    for (int v = 0; v < n; v++)
      if (sz(adj[v])) iter_swap(begin(adj[v]),
max_element(all(adj[v]), [&](int a, int b) { return
make_pair(a != p[v], sub[a]) < make_pair(b != p[v],
sub[b]); }));
    function<void(int)> dfs = [&](int v) {
      tin[v] = timer++;
      for (auto &to : adj[v])
        if (to != p[v]) {
```

```
          top[to] = (to == adj[v][0] ? top[v] :
to);
          dfs(to);
        }
    };
    dfs(0);
  }
  int lca(int u, int v) {
    return process(u, v, [](...) {});
  }
  template <class B>
  int process(int a, int b, B op, bool ignore_lca =
false) {
    for (int v;; op(tin[v], tin[b]), b = p[v]) {
      if (tin[a] > tin[b]) swap(a, b);
      if ((v = top[b]) == top[a]) break;
    }
    if (int l = tin[a] + ignore_lca, r = tin[b]; l
<= r) op(l, r);
    return a;
  }
  template <class B>
  void subtree(int v, B op, bool ignore_lca =
false) {
    if (sub[v] > 1 or !ignore_lca) op(tin[v] +
ignore_lca, tin[v] + sub[v] - 1);
  }
};
```

3.6. KthAnc.h

```
struct LCA {
  int n;
  vvi& adjLists;
  int lg;
  vvi up;
  vi depth;
  LCA(vvi& _adjLists, int root = 0) :
n(sz(_adjLists)), adjLists(_adjLists) {
    lg = 1;
    int pw = 1;
    while (pw <= n) pw <<= 1, lg++;
    // lg = 20
    up = vvi(n, vi(lg));
    depth.assign(n, -1);
    function<void(int, int)> parentDFS = [&](int
from, int parent) {
      depth[from] = depth[parent] + 1;
      up[from][0] = parent;
      for (auto to : adjLists[from]) {
        if (to == parent) continue;
        parentDFS(to, from);
      }
    };
    parentDFS(root, root);
    for (int j = 1; j < lg; j++) {
      for (int i = 0; i < n; i++) {
        up[i][j] = up[up[i][j - 1]][j - 1];
      }
    }
  }
```

```
  int kthAnc(int v, int k) {
    int ret = v;
    int pw = 0;
    while (k) {
      if (k & 1) ret = up[ret][pw];
      k >>= 1;
      pw++;
    }
    return ret;
  }
  int lca(int u, int v) {
    if (depth[u] > depth[v]) swap(u, v);
    v = kthAnc(v, depth[v] - depth[u]);
    if (u == v) return v;
    while (up[u][0] != up[v][0]) {
      int i = 0;
      for (; i < lg - 1; i++) {
        if (up[u][i + 1] == up[v][i + 1]) break;
      }
      u = up[u][i], v = up[v][i];
    }
    return up[u][0];
  };
  int dist(int u, int v) {
    return depth[u] + depth[v] - 2 * depth[lca(u,
v)];
  }
};
```

3.7. MinCostMaxFlow.h

```
template <const int MAX_N, typename flow_t,
typename cost_t, flow_t FLOW_INF,
cost_t COST_INF, const int SCALE = 16>
struct CostScalingMCMF {
#define sz(a) a.size()
#define zero_stl(v, sz) fill(v.begin(), v.begin() +
(sz), 0)
  struct Edge {
    int v;
    flow_t c;
    cost_t d;
    int r;
    Edge() = default;
    Edge(int v, flow_t c, cost_t d, int r) : v(v),
c(c), d(d), r(r) {}
  };
  vector<Edge> g[MAX_N];
  cost_t negativeSelfLoop;
  array<cost_t, MAX_N> pi, excess;
  array<int, MAX_N> level, ptr;
  CostScalingMCMF() { negativeSelfLoop = 0; }
  void clear() {
    negativeSelfLoop = 0;
    for (int i = 0; i < MAX_N; i++) g[i].clear();
  }
  void addEdge(int s, int e, flow_t cap, cost_t
cost) {
    if (s == e) {
      if (cost < 0) negativeSelfLoop += cap * cost;
      return;
```

```
    }
    g[s].push_back(Edge(e, cap, cost, sz(g[e])));
    g[e].push_back(Edge(s, 0, -cost, sz(g[s]) -
1));
  }
  flow_t getMaxFlow(int V, int S, int T) {
    auto BFS = [&]() {
      zero_stl(level, V);
      queue<int> q;
      q.push(S);
      level[S] = 1;
      for (q.push(S); !q.empty(); q.pop()) {
        int v = q.front();
        for (const auto &e : g[v])
          if (!level[e.v] && e.c) q.push(e.v),
level[e.v] = level[v] + 1;
      }
      return level[T];
    };
    function<flow_t(int, flow_t)> DFS = [&](int v,
flow_t fl) {
      if (v == T || fl == 0) return fl;
      for (int &i = ptr[v]; i < (int)g[v].size();
i++) {
        Edge &e = g[v][i];
        if (level[e.v] != level[v] + 1 || !e.c)
continue;
        flow_t delta = DFS(e.v, min(fl, e.c));
        if (delta) {
          e.c -= delta;
          g[e.v][e.r].c += delta;
          return delta;
        }
      }
      return flow_t(0);
    };
    flow_t maxFlow = 0, tmp = 0;
    while (BFS()) {
      zero_stl(ptr, V);
      while ((tmp = DFS(S, FLOW_INF))) maxFlow +=
tmp;
    }
    return maxFlow;
  }
  pair<flow_t, cost_t> maxflow(int N, int S, int T)
{
    flow_t maxFlow = 0;
    cost_t eps = 0, minCost = 0;
    stack<int, vector<int>> stk;
    auto c_pi = [&](int v, const Edge &edge)
{ return edge.d + pi[v] - pi[edge.v]; };
    auto push = [&](int v, Edge &edge, flow_t
delta, bool flag) {
      delta = min(delta, edge.c);
      edge.c -= delta;
      g[edge.v][edge.r].c += delta;
      excess[v] -= delta;
      excess[edge.v] += delta;
      if (flag && 0 < excess[edge.v] &&
excess[edge.v] <= delta) stk.push(edge.v);
```

```
    };
    auto relabel = [&](int v, cost_t delta) { pi[v]
-= delta + eps; };
    auto lookAhead = [&](int v) {
      if (excess[v]) return false;
      cost_t delta = COST_INF;
      for (auto &e : g[v]) {
        if (e.c <= 0) continue;
        cost_t cp = c_pi(v, e);
        if (cp < 0)
          return false;
        else
          delta = min(delta, cp);
      }
      relabel(v, delta);
      return true;
    };
    auto discharge = [&](int v) {
      cost_t delta = COST_INF;
      for (int i = 0; i < sz(g[v]); i++) {
        Edge &e = g[v][i];
        if (e.c <= 0) continue;
        cost_t cp = c_pi(v, e);
        if (cp < 0) {
          if (lookAhead(e.v)) {
            i--;
            continue;
          }
          push(v, e, excess[v], true);
          if (excess[v] == 0) return;
        } else
          delta = min(delta, cp);
      }
      relabel(v, delta);
      stk.push(v);
    };
    zero_stl(pi, N);
    zero_stl(excess, N);
    for (int i = 0; i < N; i++)
      for (auto &e : g[i]) minCost += e.c * e.d,
e.d *= MAX_N + 1, eps = max(eps, e.d);
    maxFlow = getMaxFlow(N, S, T);
    while (eps > 1) {
      eps /= SCALE;
      if (eps < 1) eps = 1;
      stk = stack<int, vector<int>>();
      for (int v = 0; v < N; v++)
        for (auto &e : g[v])
          if (c_pi(v, e) < 0 && e.c > 0) push(v, e,
e.c, false);
      for (int v = 0; v < N; v++)
        if (excess[v] > 0) stk.push(v);
      while (stk.size()) {
        int top = stk.top();
        stk.pop();
        discharge(top);
      }
    }
    for (int v = 0; v < N; v++)
      for (auto &e : g[v]) e.d /= MAX_N + 1,
```

```
minCost -= e.c * e.d;
    minCost = minCost / 2 + negativeSelfLoop;
    return {maxFlow, minCost};
  }
};

void solve() {
  CostScalingMCMF<102, int, int, 100, 100> flow;
  int n, m;
  cin >> n >> m;
  int start = 0;
  for (int i = 0; i < n; i++) {
    for (int j = 0; j < m; j++) {
      int inp;
      cin >> inp;
      if (inp) {
        flow.addEdge(i + 1, n + 1 + j, 1, 0);
        start++;
      } else
        flow.addEdge(i + 1, n + 1 + j, 1, 1);
    }
  }
  int counta = 0, countb = 0;
  for (int i = 0; i < n; i++) {
    int inp;
    cin >> inp;
    counta += inp;
    flow.addEdge(0, i + 1, inp, 0);
  }
  for (int i = 0; i < m; i++) {
    int inp;
    cin >> inp;
    countb += inp;
    flow.addEdge(n + i + 1, n + m + 1, inp, 0);
  }
  if (counta != countb) {
    cout << -1 << endl;
    return;
  }
  pii t = flow.maxflow(102, 0, n + m + 1);
  if (t.first != counta) {
    cout << -1 << endl;
    return;
  }
  cout << t.second + start + t.second - counta <<
endl;
}
```

4. Number Theory

4.1. MillerRabin.h

```
u64 mult(u64 a, u64 b, u64 m = M) {
    i64 ret = a * b - m * (u64)(1.L / m * a * b);
    return ret + m * (ret < 0) - m * (ret >=
(i64)m);
}
u64 pw(u64 b, u64 e, u64 m = M) {
    u64 ret = 1;
    for (; e; b = mult(b, b, m), e >>= 1)
        if (e & 1) ret = mult(ret, b, m);
    return ret;
```

```
}
bool isPrime(u64 n) { // determistic upto 7e^18
    if (n < 2 || n % 6 % 4 != 1) return (n | 1) ==
3;
    u64 A[] = {2, 325, 9375, 28178, 450775,
9780504, 1795265022},
        s = __builtin_ctzll(n - 1), d = n >> s;
    for (u64 a : A) {
        u64 p = pw(a % n, d, n), i = s;
        while (p != 1 && p != n - 1 && a % n &&
i--)
            p = mult(p, p, n);
        if (p != n - 1 && i != s) return 0;
    }
    return 1;
}
```

4.2. gcdextended.h

```
int euclid(int a, int b, int &x, int &y) {
  if (!b) return x = 1, y = 0, a;
  int d = euclid(b, a % b, y, x);
  return y -= a / b * x, d;
}
```

4.3. spf.h

```
#define SIEVE_TILL (int)1e6
vector<int> primes;
vector<int> spf;
void sieve() {
  spf = vector<int>(SIEVE_TILL + 1, 0);
  for (int i = 2; i <= SIEVE_TILL; i++) {
    if (spf[i] == 0) primes.push_back(i), spf[i] =
i;
    for (int j = 0; j < sz(primes) and i *
primes[j] <= SIEVE_TILL; j++) {
      spf[i * primes[j]] = primes[j];
      if (spf[i] == primes[j]) break;
    }
  }
}
bool isPrime(int n) {
  if (n <= 1) return false;
  return spf[n] == n;
}
```

5. Strings

5.1. Manacher.h

```
/* Description: p[0][i] = half length of longest
even palindrome behind pos i,
p[1][i] = longest odd with center at pos i(half
rounded down). */
array<vi, 2> manacher(const string& s) {
    int n = sz(s);
    array<vi, 2> p = {vi(n + 1), vi(n)};
    for (int z = 0; z < 2; z++) for (int i = 0, l =
0, r = 0; i < n; i++) {
        int t = r - i + !z;
        if (i < r) p[z][i] = min(t, p[z][l + t]);
        int L = i - p[z][i], R = i + p[z][i] - !z;
        while (L >= 1 && R + 1 < n && s[L - 1] ==
s[R + 1])
```

```
            p[z][i]++, L--, R++;
        if (R > r) l = L, r = R;
    }
    return p;
}
```

5.2. Trie.h

```
struct trieobject {
  trieobject() {
    children[0] = NULL;
    children[1] = NULL;
    numelems = 0;
  };

  struct trieobject* children[2];
  int numelems;
};
struct trie {
  trieobject base;
  trie() {
    trieobject base;
  }
  void add(int x) {
    int pow2 = (1ll << 31ll);
    trieobject* temp = &base;
    while (pow2 > 0) {
      if (temp->children[1 && (x & pow2)] == NULL)
{
        temp->children[1 && (x & pow2)] = new
trieobject;
      }
      temp->children[1 && (x & pow2)]->numelems++;
      temp = temp->children[1 && (x & pow2)];
      pow2 /= 2;
    }
  }
  // ADD FUNCTION BELOW
};
```

5.3. SuffixArray.h

```
/*Builds suffix array for a string.
\texttt{sa[i]} is the starting index of the suffix
which
is $i$'th in the sorted suffix array.
The returned vector is of size $n+1$, and
\texttt{sa[0] = n}.
The \texttt{lcp} array contains longest common
prefixes for
neighbouring strings in the suffix array:
\texttt{lcp[i] = lcp(sa[i], sa[i-1])},
\texttt{lcp[0] = 0}.
The input string must not contain any zero bytes.
Time: O(n \log n)*/
#define rep(i, j, k) for (int i = j; i < k; i++)
struct SuffixArray {
  vi sa, lcp;
  SuffixArray(string& s, int lim=256) { // or
basic_string<int>
    int n = sz(s) + 1, k = 0, a, b;
    vi x(all(s)), y(n), ws(max(n, lim));
```

```
    x.push_back(0), sa = lcp = y, iota(all(sa), 0);
    for (int j = 0, p = 0; p < n; j = max(1, 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 (int i = n; i--;) sa[--ws[x[y[i]]]] =
y[i];
      swap(x, y), p = 1, x[sa[0]] = 0;
      rep(i,1,n) a = sa[i - 1], b = sa[i], x[b] =
        (y[a] == y[b] && y[a + j] == y[b + j]) ? p
- 1 : p++;
    }
    for (int i = 0, j; i < n - 1; lcp[x[i++]] = k)
      for (k && k--, j = sa[x[i] - 1];
          s[i + k] == s[j + k]; k++);
  }
};
```

6. Numerical

6.1. NTT.h

```
/* Description: Can be used for convolutions modulo
specific nice primes of the form 2^a b+1, where the
convolution result has size at most 2^a
 * (125000001 << 3) + 1 = 1e9 + 7, therefore do not
use this for M = 1e9 + 7.
 * For $p < 2^30$ there is also e.g. (5 << 25, 3),
(7 << 26, 3),
 * For other primes/integers, use two different
primes and combine with CRT. (479 << 21, 3) and
(483 << 21, 5). The last two are > 10^9
 * Inputs must be in [0, mod).
 */
// Requires mod func
const int M = 998244353;
const int root = 3;
// (119 << 23) + 1, root = 3;  // for M = 998244353
void ntt(int* x, int* temp, int* roots, int N, int
skip) {
  if (N == 1) return;
  int n2 = N / 2;
  ntt(x, temp, roots, n2, skip * 2);
  ntt(x + skip, temp, roots, n2, skip * 2);
  for (int i = 0; i < N; i++) temp[i] = x[i *
skip];
  for (int i = 0; i < n2; i++) {
    int s = temp[2 * i], t = temp[2 * i + 1] *
roots[skip * i];
    x[skip * i] = (s + t) % M;
    x[skip * (i + n2)] = (s - t) % M;
  }
}
void ntt(vi& x, bool inv = false) {
  int e = pw(root, (M - 1) / sz(x));
  if (inv) e = pw(e, M - 2);
  vi roots(sz(x), 1), temp = roots;
  for (int i = 1; i < sz(x); i++) roots[i] =
```

```
roots[i - 1] * e % M;
  ntt(&x[0], &temp[0], &roots[0], sz(x), 1);
}
// Usage: just pass the two coefficients list to
get a*b (modulo M)
vi conv(vi a, vi b) {
  int s = sz(a) + sz(b) - 1;
  if (s <= 0) return {};
  int L = s > 1 ? 32 - __builtin_clzll(s - 1) : 0,
n = 1 << L;
  if (s <= 200) {  // (factor 10 optimization for |
a|,|b| = 10)
    vi c(s);
    for (int i = 0; i < sz(a); i++)
      for (int j = 0; j < sz(b); j++)
        c[i + j] = (c[i + j] + a[i] * b[j]) % M;
    return c;
  }
  a.resize(n);
  ntt(a);
  b.resize(n);
  ntt(b);
  vi c(n);
  int d = pw(n, M - 2);
  for (int i = 0; i < n; i++) c[i] = a[i] * b[i] %
M * d % M;
  ntt(c, true);
  c.resize(s);
  return c;
}
```

6.2. FastFourierTransform.h

```
typedef complex<double> C;
typedef vector<double> vd;

void fft(vector<C>& a) {
  int n = sz(a), L = 31 - __builtin_clz(n);
  static vector<complex<long double>> R(2, 1);
  static vector<C> rt(2, 1);  // (^ 10% faster if
double)
  for (static int k = 2; k < n; k *= 2) {
    R.resize(n); rt.resize(n);
    auto x = polar(1.0L, acos(-1.0L) / k);
    rep(i,k,2*k) rt[i] = R[i] = i&1 ? R[i/2] * x :
R[i/2];
  }
  vi rev(n);
  rep(i,0,n) rev[i] = (rev[i / 2] | (i & 1) << L) /
2;
  rep(i,0,n) if (i < rev[i]) swap(a[i], a[rev[i]]);
  for (int k = 1; k < n; k *= 2)
    for (int i = 0; i < n; i += 2 * k) rep(j,0,k) {
      // C z = rt[j+k] * a[i+j+k]; // (25% faster
if hand-rolled)  /// include-line
      auto x = (double *)&rt[j+k], y = (double
*)&a[i+j+k];        /// exclude-line
      C z(x[0]*y[0] - x[1]*y[1], x[0]*y[1] +
x[1]*y[0]);          /// exclude-line
      a[i + j + k] = a[i + j] - z;
      a[i + j] += z;
    }
```

```
}
vd conv(const vd& a, const vd& b) {
  if (a.empty() || b.empty()) return {};
  vd res(sz(a) + sz(b) - 1);
  int L = 32 - __builtin_clz(sz(res)), n = 1 << L;
  vector<C> in(n), out(n);
  copy(all(a), begin(in));
  rep(i,0,sz(b)) in[i].imag(b[i]);
  fft(in);
  for (C& x : in) x *= x;
  rep(i,0,n) out[i] = in[-i & (n - 1)] -
conj(in[i]);
  fft(out);
  rep(i,0,sz(res)) res[i] = imag(out[i]) / (4 * n);
  return res;
}
```

7. Geometry

7.1. ConvexHull.h

```
// Needs point
typedef Point<ll> P;
vector<P> convexHull(vector<P> pts) {
  if (sz(pts) <= 1) return pts;
  sort(all(pts));
  vector<P> h(sz(pts)+1);
  int s = 0, t = 0;
  for (int it = 2; it--; s = --t,
reverse(all(pts)))
    for (P p : pts) {
      while (t >= s + 2 && h[t-2].cross(h[t-1], p)
<= 0) t--;
      h[t++] = p;
    }
  return {h.begin(), h.begin() + t - (t == 2 &&
h[0] == h[1])};
}
```

7.2. Point.h

```
template <class T>
int sgn(T x) { return (x > 0) - (x < 0); }
template <class T>
struct Point {
  typedef Point P;
  T x, y;
  explicit Point(T x = 0, T y = 0) : x(x), y(y) {}
  bool operator<(P p) const { return tie(x, y) <
tie(p.x, p.y); }
  bool operator==(P p) const { return tie(x, y) ==
tie(p.x, p.y); }
  P operator+(P p) const { return P(x + p.x, y +
p.y); }
  P operator-(P p) const { return P(x - p.x, y -
p.y); }
  P operator*(T d) const { return P(x * d, y *
d); }
  P operator/(T d) const { return P(x / d, y /
d); }
  T dot(P p) const { return x * p.x + y * p.y; }
  T cross(P p) const { return x * p.y - y * p.x; }
  T cross(P a, P b) const { return (a -
```

```
*this).cross(b - *this); }
  T dist2() const { return x * x + y * y; }
  double dist() const { return
sqrt((double)dist2()); }
  // angle to x-axis in interval [-pi, pi]
  double angle() const { return atan2(y, x); }
  P unit() const { return *this / dist(); }  //
makes dist()=1
  P perp() const { return P(-y, x); }        //
rotates +90 degrees
  P normal() const { return perp().unit(); }
  // returns point rotated 'a' radians ccw around
the origin
  P rotate(double a) const {
    return P(x * cos(a) - y * sin(a), x * sin(a) +
y * cos(a));
  }
  friend ostream& operator<<(ostream& os, P p) {
    return os << "(" << p.x << "," << p.y << ")";
  }
};
```

7.3. ClosestPair.h

```
// Requires point
typedef Point<int> P;
pair<P, P> closest(vector<P> v) {
  assert(sz(v) > 1);
  set<P> S;
  sort(all(v), [](P a, P b) { return a.y < b.y; });
  pair<int, pair<P, P>> ret{LLONG_MAX, {P(), P()}};
  int j = 0;
  for (P p : v) {
    P d{1 + (int)sqrtl(ret.first), 0};
    while (v[j].y <= p.y - d.x) S.erase(v[j++]);
    auto lo = S.lower_bound(p - d), hi =
S.upper_bound(p + d);
    for (; lo != hi; ++lo)
      ret = min(ret, {(*lo - p).dist2(), {*lo,
p}});
    S.insert(p);
  }
  return ret.second;
}
```