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1. DataStructure

1.1. 2DBIT.cpp

```

1
2
3 using namespace std;
4 #define LL long long
5 #define pii pair<int, int>
6 #define N 1005
7 #define F first
8 #define S second
9 int bit[N][N];
10 #define lb(x) (x & -x)
11 void upd(int i, int j, int v) {
12     for(; j < N; j += lb(j))
13         for(int k = i; k < N; k += lb(k)) bit[k][j] += v;
14 }
15 int qry2(int i, int j) {
16     int ans = 0;
17     for(; j; j -= lb(j))
18         for(int k = i; k; k -= lb(k)) ans += bit[k][j];
19     return ans;
20 }
21 int qry(int y1, int x1, int y2, int x2) {
22     return qry2(y2, x2) - qry2(y2, x1 - 1) - qry2(y1 - 1, x2) +
23         qry2(y1 - 1, x1 - 1);
24 }
25 int main() {
26     int n, q, i = 1, j, y, x;
27     for(scanf("%d %d", &n, &q); getchar(), i <= n; ++i)
28         for(j = 1; j <= n; ++j)
29             if(getchar() == '*') upd(i, j, 1);
30     for(q--; q > 0; --q) {
31         scanf("%d", &i);
32         if(i == 1)
33             scanf("%d %d", &i, &j),
34             upd(i, j, 1 - 2 * qry(i, j, i, j));
35         else
36             scanf("%d %d %d %d", &i, &j, &y, &x),
37             printf("%d\n", qry(i, j, y, x));
38     }
39 }

```

1.2. DynamicSegmentTree.cpp

```

1
2 #define int long long
3 using namespace std;
4
5 int n, q;
6 struct node {
7     int data, lson, rson, tag;
8     int rv() { return data + tag; }
9 };
10
11 node tree[20000005];
12 int a[2000005];
13 int now = 1;
14 int mx = 1000000005;

```

```

15 void push(int index) {
17     if(!tree[index].lson) {
19         tree[index].lson = ++now;
21     }
23     if(!tree[index].rson) {
25         tree[index].rson = ++now;
27     }
29     int lson = tree[index].lson;
31     int rson = tree[index].rson;
33     tree[lson].tag += tree[index].tag;
35     tree[rson].tag += tree[index].tag;
37     tree[index].data = tree[index].rv();
39     tree[index].tag = 0;
41 }

43 void modify(int l, int r, int L, int R, int val, int index) {
45     if(l == L && r == R) {
47         tree[index].tag += val;
49         return;
51     }
53     int mid = (l + r) >> 1;
55     push(index);
57     int lson = tree[index].lson;
59     int rson = tree[index].rson;
61     if(R <= mid) {
63         modify(l, mid, L, R, val, lson);
65     } else if(L > mid) {
67         modify(mid + 1, r, L, R, val, rson);
69     } else {
71         modify(l, mid, L, mid, val, lson);
73         modify(mid + 1, r, mid + 1, R, val, rson);
75     }
77     tree[index].data = tree[lson].rv() + tree[rson].rv();
79 }

81 int query(int l, int r, int L, int R, int index) {
83     // cout << L << " " << R << "\n";
85     if(l == L && r == R) {
87         return tree[index].rv();
89     }
91     int mid = (l + r) >> 1;
93     push(index);
95     int lson = tree[index].lson;
97     int rson = tree[index].rson;
99     if(R <= mid) {
101         return query(l, mid, L, R, lson);
103     }
105     if(L > mid) {
107         return query(mid + 1, r, L, R, rson);
109     }
111     return query(l, mid, L, mid, lson) +
112         query(mid + 1, r, mid + 1, R, rson);
113 }

115 signed main() {
117     ios::sync_with_stdio(0);
119     cin.tie(0);
121     cout.tie(0);
123     cin >> n >> q;
125     for(int i = 1; i <= n; i++) {
127         cin >> a[i];
129         modify(1, mx, a[i], a[i], 1, 1);
131     }
133     while(q--) {
135         char mode;
137         int x, y;
139         cin >> mode;
141         if(mode == '?') {
143             cin >> x >> y;
145             cout << query(1, mx, x, y, 1) << "\n";
147         } else {
149             cin >> x >> y;
151             modify(1, mx, a[x], a[x], -1, 1);
153             a[x] = y;
155             modify(1, mx, a[x], a[x], 1, 1);
157         }
159     }
161 }

```

1.3. PbdsGpHashTable.cpp

```

1 using namespace __gnu_pbds;
3 #define ull unsigned ll
5 mt19937 mt(hash<string>("164253_official_beautiful_fruit"));
7 struct myhash {
9     static ull splitmix64(ull x) {
11         x += 0x9e3779b97f4a7c15;
13         x = (x ^ (x >> 30)) * 0xbf58476d1ce4e5b9;
15         x = (x ^ (x >> 27)) * 0x94d049bb133111eb;
17         return x ^ (x >> 31);
19     }

```

```

13 ull operator()(ull x) const {
15     static const ull FIXED_RANDOM =
17         (ull)make_unique<char>().get() ^
19         chrono::high_resolution_clock::now()
21         .time_since_epoch()
23         .count();
25     // static const ull FIXED_RANDOM=mt();
27     // static const ull
29     // FIXED_RANDOM=chrono::steady_clock::now()
31     // .time_since_epoch().count();
33     return splitmix64(x + FIXED_RANDOM);
35 }
37 };
39 gp_hash_table<ull,ull,myhash> gp;
41 gp[x]=y;
43 if(gp.find(x)!=gp.end())cout<<gp[x];
45 gp.count(); //CE
47 */

```

1.4. PbdsPriorityQueue.cpp

```

1 __gnu_pbds::priority_queue<int> pq;
3 /*
5 push(x); //return iterator
7 pop() top() join(pq2) erase(iter) modify(iter,x)
9 */

```

1.5. PbdsRope.cpp

```

1 using namespace __gnu_cxx;
3 /*
5 rope<int> r;
7 r.erase(pos,k); //r=r.[0,pos)+r.[pos+k,r.length());
9 push_back(x) pop_back() insert(pos,x) clear() find(x)
11 lower_bound(all(r),x) upper_bound //same as vector
13 r.length(); //same as .length
15 r.replace(pos,len=r.length(),x); //r.[pos,pos+len)=x;
17 r.substr(pos,x); //return r.[pos,pos+x);
19 rope<char> s="official_beautiful_fruit";
21 cout<<s; //it's legal
23 */

```

1.6. PbdsTree.cpp

```

1 using namespace __gnu_pbds;
3 /*
5 tree<int,null_type,less<int>,rb_tree_tag,
7 tree_order_statistics_node_update> tr;
9 //same as rope<int>, except tr.lower_bound(x) and upper_bound
11 tr.find_by_order(k); //return kth iterator; k=[0,tr.size())
13 //out of this will get tr.end()
15 tr.order_of_key(val); //return rank(val);
17 tr.join(tr2); //merge tr
19 and tr2, tr2.clear() tr.split(const int&r,RBTree&tr2); //<r
21 will in tr, >=r will in tr2
23 */

```

1.7. PersistentSegmentTree.cpp

```

1 // cses Range Queries and Copies
3 using namespace std;
5 #define LL long long
7 #define pii pair<int, int>
9 #define N 200005
11 #define F first
13 #define S second
15 int n, ver = 1;
17 LL a[N];
19 struct Seg {
21     LL v = 0;
23     struct Seg *l = NULL, *r = NULL;
25 }
27 #define M (L + R >> 1)
29 static const void init(Seg *node, int L = 1, int R = n) {
31     if(L == R) {
33         node->v = a[L];
35         return;
37     }
39     node->l = new Seg();
41     init(node->l, L, M);
43     node->r = new Seg();
45     init(node->r, M + 1, R);
47     node->v = node->l->v + node->r->v;
49 }
51 static const void upd(Seg *node, int x, LL v, int L = 1,
53 int R = n) {
55     if(L == R) {
57         node->v = v;
59     }

```

```

        return;
    }
    if(x <= M)
        node->l = new Seg(*node->l),
        upd(node->l, x, v, L, M);
    else
        node->r = new Seg(*node->r),
        upd(node->r, x, v, M + 1, R);
    node->v = node->l->v + node->r->v;
}
static const LL qry(Seg *node, int l, int r, int L = 1,
                    int R = n) {
    if(l <= L && R <= r) return node->v;
    if(r <= M) return qry(node->l, l, r, L, M);
    if(M + 1 <= l) return qry(node->r, l, r, M + 1, R);
    return qry(node->l, l, M, L, M) +
           qry(node->r, M + 1, r, M + 1, R);
}
} * tree[N];
int main() {
    ios::sync_with_stdio(0);
    cin.tie(0);
    cout.tie(0);
    int q, i = 1, j, k;
    for(cin >> n >> q; i <= n; ++i) cin >> a[i];
    tree[1] = new Seg();
    Seg::init(tree[1]);
    for(; q--;) {
        cin >> i >> k;
        if(i == 1)
            cin >> i >> j, Seg::upd(tree[k], i, j);
        else if(i == 2)
            cin >> i >> j,
            cout << Seg::qry(tree[k], i, j) << "\n";
        else
            tree[++ver] = new Seg(*tree[k]);
    }
}

```

1.8. Treap.cpp

```

#define pii pair<int, int>
struct node {
    int tag = 0;
    int sum = 0;
    int prio = rand();
    int lson = 0;
    int rson = 0;
    int si = 0;
    int val = 0;
};
node treap[400005];
int cnt = 0;
int root = 0;

void update(int index) {
    int lson = treap[index].lson;
    int rson = treap[index].rson;
    treap[index].si = treap[lson].si + treap[rson].si + 1;
    treap[index].sum = treap[lson].sum;
    treap[index].sum += treap[rson].sum;
    treap[index].sum += treap[index].val;
}

void push(int index) {
    if(!treap[index].tag) return;
    swap(treap[index].lson, treap[index].rson);
    int lson = treap[index].lson;
    int rson = treap[index].rson;
    treap[lson].tag ^= 1;
    treap[rson].tag ^= 1;
    treap[index].tag = 0;
}

pii split(int rk, int index) {
    if(!index) return {0, 0};
    push(index);
    int lson = treap[index].lson;
    int rson = treap[index].rson;
    if(rk <= treap[lson].si) {
        pii temp = split(rk, lson);
        treap[index].lson = temp.second;
        update(index);
        return {temp.first, index};
    } else {
        pii temp = split(rk - treap[lson].si - 1, rson);
        treap[index].rson = temp.first;
        update(index);
        return {index, temp.second};
    }
}

int merge(int x, int y) {
    if(!x && !y) return 0;

```

```

    if(!x && y) return y;
    if(x && !y) return x;
    push(x);
    push(y);
    if(treap[x].prio < treap[y].prio) {
        treap[x].rson = merge(treap[x].rson, y);
        update(x);
        return x;
    } else {
        treap[y].lson = merge(x, treap[y].lson);
        update(y);
        return y;
    }
}

void insert(int x, int v) {
    pii temp = split(x - 1, root);
    cnt++;
    treap[cnt].val = v;
    update(cnt);
    temp.first = merge(temp.first, cnt);
    root = merge(temp.first, temp.second);
}

int query(int l, int r) {
    pii R = split(r, root);
    pii L = split(l - 1, R.first);
    int ret = treap[L.second].sum;
    R.first = merge(L.first, L.second);
    root = merge(R.first, R.second);
    return ret;
}

void modify(int l, int r) {
    pii R = split(r, root);
    pii L = split(l - 1, R.first);
    treap[L.second].tag ^= 1;
    R.first = merge(L.first, L.second);
    root = merge(R.first, R.second);
}

```

2. Math

2.1. CRT.cpp

```

#define int long long
using namespace std;

int n;
int a[15];
int b[15];
int mul = 1;

void exgcd(int a, int b, int &x, int &y) {
    if(b == 0) {
        x = 1;
        y = 0;
        return;
    }
    exgcd(b, a % b, y, x);
    y -= (a / b) * x;
}

int inv(int a, int p) {
    int x, y;
    exgcd(a, p, x, y);
    return x;
}

int ans = 0;

signed main() {
    cin >> n;
    for(int i = 1; i <= n; i++) {
        cin >> a[i] >> b[i];
        mul *= a[i];
    }
    for(int i = 1; i <= n; i++) {
        ans += inv(mul / a[i], a[i]) * (mul / a[i]) % mul *
            b[i] % mul;
        ans %= mul;
    }
    ans = (ans + mul) % mul;
    cout << ans;
}

```

2.2. CountPrimes.cpp

```

using namespace std;
using i64 = long long;

```

```

5 i64 count_pi(i64 N) {
6     if(N <= 1) return 0;
7     int v = sqrt(N + 0.5);
8     int n_4 = sqrt(v + 0.5);
9     int T = min((int)sqrt(n_4) * 2, n_4);
10    int K = pow(N, 0.625) / log(N) * 2;
11    K = max(K, v);
12    K = min<i64>(K, N);
13    int B = N / K;
14    B = N / (N / B);
15    B = min<i64>(N / (N / B), K);

16    vector<i64> l(v + 1);
17    vector<int> s(K + 1);
18    vector<bool> e(K + 1);
19    vector<int> w(K + 1);
20    for(int i = 1; i <= v; ++i) l[i] = N / i - 1;
21    for(int i = 1; i <= v; ++i) s[i] = i - 1;

22    const auto div = [](i64 n, int d) -> int {
23        return double(n) / d;
24    };
25    int p;
26    for(p = 2; p <= T; ++p)
27        if(s[p] != s[p - 1]) {
28            i64 M = N / p;
29            int t = v / p, t0 = s[p - 1];
30            for(int i = 1; i <= t; ++i) l[i] -= l[i * p] - t0;
31            for(int i = t + 1; i <= v; ++i)
32                l[i] -= s[div(M, i)] - t0;
33            for(int i = v, j = t; j >= p; --j)
34                for(int l = j * p; i >= l; --i)
35                    s[i] -= s[j] - t0;
36            for(int i = p * p; i <= K; i += p) e[i] = 1;
37        }
38    e[1] = 1;
39    int cnt = 1;
40    vector<int> roughs(B + 1);
41    for(int i = 1; i <= B; ++i)
42        if(!e[i]) roughs[cnt++] = i;
43    roughs[cnt] = 0x7fffffff;
44    for(int i = 1; i <= K; ++i) w[i] = e[i] + w[i - 1];
45    for(int i = 1; i <= K; ++i) s[i] = w[i] - w[i - (i & -i)];

46    const auto query = [&](int x) -> int {
47        int sum = x;
48        while(x) sum -= s[x], x ^= x & -x;
49        return sum;
50    };
51    const auto add = [&](int x) -> void {
52        e[x] = 1;
53        while(x <= K) ++s[x], x += x & -x;
54    };
55    cnt = 1;
56    for(; p <= n_4; ++p)
57        if(!e[p]) {
58            i64 q = i64(p) * p, M = N / p;
59            while(cnt < q) w[cnt] = query(cnt), cnt++;
60            int t1 = B / p, t2 = min<i64>(B, M / q),
61                t0 = query(p - 1);
62            int id = 1, i = 1;
63            for(; i <= t1; i = roughs[++id])
64                l[i] -= l[i * p] - t0;
65            for(; i <= t2; i = roughs[++id])
66                l[i] -= query(div(M, i)) - t0;
67            for(; i <= B; i = roughs[++id])
68                l[i] -= w[div(M, i)] - t0;
69            for(int i = q; i <= K; i += p)
70                if(!e[i]) add(i);
71        }
72    while(cnt <= v) w[cnt] = query(cnt), cnt++;

73    vector<int> primes;
74    primes.push_back(1);
75    for(int i = 2; i <= v; ++i)
76        if(!e[i]) primes.push_back(i);
77    l[1] += i64(w[v] + w[n_4] - 1) * (w[v] - w[n_4]) / 2;
78    for(int i = w[n_4] + 1; i <= w[B]; ++i)
79        l[1] -= l[primes[i]];
80    for(int i = w[B] + 1; i <= w[v]; ++i)
81        l[1] -= query(N / primes[i]);
82    for(int i = w[n_4] + 1; i <= w[v]; ++i) {
83        int q = primes[i];
84        i64 M = N / q;
85        int e = w[M / q];
86        if(e <= i) break;
87        l[1] += e - i;
88        i64 t = 0;
89        int m = w[sqrt(M + 0.5)];
90        for(int k = i + 1; k <= m; ++k)
91            t += w[div(M, primes[k])];
92        l[1] += 2 * t - (i + m) * (m - i);
93    }
94 }

```

```

97     return l[1];
98 }

```

2.3. FFT.cpp

```

1 using namespace std;
2 inline int read() {
3     int ans = 0;
4     char c = getchar();
5     while(!isdigit(c)) c = getchar();
6     while(isdigit(c)) {
7         ans = ans * 10 + c - '0';
8         c = getchar();
9     }
10    return ans;
11 }
12 typedef complex<double> comp;
13 const int MAXN = 1000005;
14 const comp I(0, 1);
15 const double PI = acos(-1);
16 comp A[MAXN * 3], B[MAXN * 3], tmp[MAXN * 3], ans[MAXN * 3];
17 void fft(comp F[], int N, int sgn = 1) {
18     if(N == 1) return;
19     memcopy(tmp, F, sizeof(comp) * N);
20     for(int i = 0; i < N; i++)
21         *(i % 2 ? F + i / 2 + N / 2 : F + i / 2) = tmp[i];
22     fft(F, N / 2, sgn), fft(F + N / 2, N / 2, sgn);
23     comp *G = F, *H = F + N / 2;
24     comp cur = 1, step = exp(2 * PI / N * sgn * I);
25     for(int k = 0; k < N / 2; k++) {
26         tmp[k] = G[k] + cur * H[k];
27         tmp[k + N / 2] = G[k] - cur * H[k];
28         cur *= step;
29     }
30     memcopy(F, tmp, sizeof(comp) * N);
31 }
32 int main() {
33     int n = read(), m = read(), N = 1 << __lg(n + m + 1) + 1;
34     for(int i = 0; i <= n; ++i) A[i] = read();
35     for(int i = 0; i <= m; ++i) B[i] = read();
36     fft(A, N), fft(B, N);
37     for(int i = 0; i < N; ++i) ans[i] = A[i] * B[i];
38     fft(ans, N, -1);
39     for(int i = 0; i <= n + m; ++i)
40         printf("%d ", int(ans[i].real() / N + 0.1));
41     return 0;
42 }

```

2.4. FWT.cpp

```

1 #define LOGN 21
2 #define N (1 << LOGN)
3 void fwt(ll f[], int rev) {
4     for(int k = 1; k < LOGN; ++k) {
5         for(int i = 0, m = 1 << k - 1; i + m < N; i += 1 << k) {
6             for(int j = 0; j < m; ++j) {
7                 ll u = f[i + j], v = f[i + j + m];
8                 f[i + j] = u + v;
9                 f[i + j + m] = u - v;
10                if(rev) f[i + j] >>= 1, f[i + j + m] >>= 1;
11            }
12        }
13    }
14 }

```

2.5. Gaussian-Jordan.cpp

```

1 #define int long long
2 using namespace std;
3
4 int n;
5 double a[105][105];
6
7 // n <= m
8 void gaussian(double a[105][105], int n, int m) {
9     int curi = 0;
10    for(int j = 0; j < m; j++) {
11        int i;
12        for(i = curi; i < n; i++) {
13            if(a[i][j]) {
14                break;
15            }
16        }
17        if(a[i][j] == 0) continue;
18        for(int k = 0; k < m; k++) {
19            swap(a[i][k], a[curi][k]);
20        }
21        for(int k = m - 1; k >= j; k--) {
22            a[curi][k] /= a[curi][j];
23        }
24    }
25 }

```

```

25     for(int i = 0; i < n; ++i) {
27         if(i != curi) {
29             for(int k = m - 1; k >= j; k--) {
31                 a[i][k] -= a[curi][k] * a[i][j];
33             }
34         }
35         curi++;
36     }
37 }

```

2.6. Generator.cpp

```

1  #define int long long
3  using namespace std;
5  int t;
7  int n, d;
9  bitset<1000005> exist;
11 bitset<1000005> vis;
13 vector<int> prime;
15 int phi[1000005];
17 void init() {
19     phi[1] = 1;
21     for(int i = 2; i <= 1000000; i++) {
23         if(!vis[i]) {
25             prime.push_back(i);
27             phi[i] = i - 1;
29             for(int j : prime) {
31                 if(i * j > 1000000) break;
33                 vis[i * j] = 1;
35                 if(i % j == 0) {
37                     phi[i * j] = phi[i] * j;
39                     break;
41                 } else {
43                     phi[i * j] = phi[i] * phi[j];
45                 }
47             }
49         }
51     }
53     exist[2] = exist[4] = 1;
55     for(int i : prime) {
57         if(i == 2) continue;
59         for(int j = i; j <= 1000000; j += i) {
61             exist[j] = 1;
63             if(j * 2 <= 1000000) {
65                 exist[j * 2] = 1;
67             }
69         }
71     }
73     vector<int> factors(int x) {
75         vector<int> v;
77         for(int i = 1; i * i <= x; i++) {
79             if(x % i == 0) {
81                 v.push_back(i);
83                 if(i * i != x) {
85                     v.push_back(x / i);
87                 }
89             }
91         }
93         return v;
95     }
97     int f(int x, int y, int mod) {
99         int ret = 1;
101        while(y) {
103            if(y & 1) {
105                ret *= x;
107                ret %= mod;
109            }
111            x *= x;
113            x %= mod;
115            y >>= 1;
117        }
119        return (ret % mod + mod) % mod;
121    }
123    vector<int> findroot(int x) {
125        vector<int> ret;
127        if(!exist[x]) return ret;
129        int phix = phi[x];
131        vector<int> fact = factors(phix);
133        int fst;
135        for(int i = 1; i <= fact.size(); i++) {
137            if(__gcd(i, x) != 1) continue;
139            bool ok = 1;
141            for(int j : fact) {
143                if(j != phix && f(i, j, x) == 1) {
145                    ok = 0;
147                }
149            }
151            if(ok) {
153                ret.push_back(i);
154            }
155        }
156        return ret;
157    }
158    signed main() {
159        ios::sync_with_stdio(0);
161        cin.tie(0);
163        cout.tie(0);
165        init();
167        cin >> t;
169        while(t--) {
171            cin >> n >> d;
173            vector<int> v = findroot(n);
175            sort(v.begin(), v.end());
177            cout << v.size() << "\n";
179            for(int i = 0; i < v.size(); i++) {
181                if(i % d == d - 1) {
183                    cout << v[i] << " ";
185                }
186            }
187            cout << "\n";
189        }
191    }

```

```

81         break;
83     }
85     if(ok) {
87         fst = i;
89         break;
91     }
93     int now = fst;
95     // cout << fst << "\n";
97     for(int i = 1; i <= phix; i++) {
99         if(__gcd(i, phix) == 1) {
101             ret.push_back(now);
103             now *= fst;
105             now %= x;
107         }
109     }
111     return ret;
113 }
115 signed main() {
117     ios::sync_with_stdio(0);
119     cin.tie(0);
121     cout.tie(0);
123     init();
125     cin >> t;
127     while(t--) {
129         cin >> n >> d;
131         vector<int> v = findroot(n);
133         sort(v.begin(), v.end());
135         cout << v.size() << "\n";
137         for(int i = 0; i < v.size(); i++) {
139             if(i % d == d - 1) {
141                 cout << v[i] << " ";
143             }
145         }
147         cout << "\n";
149     }
151 }

```

2.7. Inv.cpp

```

1  int exgcd(int a, int b, int &x, int &y) {
3      if(b == 0) {
5          x = 1;
7          y = 0;
9          return a;
11     }
13     int d = exgcd(b, a % b, y, x);
15     y -= x * (a / b);
17     return d;
19 }
21 int inv(int a, int p) {
23     int x, y;
25     exgcd(a, p, x, y);
27     return (x % p + p) % p;
29 }

```

2.8. Lucas.cpp

```

1  int fact[1000005];
3  int p;
5  void init() {
7      fact[0] = 1;
9      for(int i = 1; i <= p; i++) {
11         fact[i] = fact[i - 1] * i % p;
13     }
15 }
17 int inv(int x, int p) {
19     if(x == 1) return 1;
21     return (p - p / x) * inv(p % x, p) % p;
23 }
25 int c(int x, int y, int p) {
27     if(x < y) return 0;
29     int k = fact[x] * inv(fact[y], p) % p;
31     return k * inv(fact[x - y], p) % p;
33 }
35 int lucas(int x, int y, int p) {
37     if(x == 0) return 1;
39     return lucas(x / p, y / p, p) % p * c(x % p, y % p, p) % p;
41 }

```

2.9. Matrix.cpp

```

1  #define int long long
3  using namespace std;

```



```

5 template <class T> T extgcd(T a, T b, T &x, T &y) {
6     if(!b) {
7         x = 1;
8         y = 0;
9         return a;
10    }
11    T ans = extgcd(b, a % b, y, x);
12    y -= a / b * x;
13    return ans;
14 }
15
16 template <class T> T modeq(T a, T b, T p) {
17     T x, y, d = extgcd(a, p, x, y);
18     if(b % d) return 0;
19     return ((b / d * x) % p + p) % p;
20 }
21
22 template <class T> class Matrix {
23     static const T MOD = 1000000007;
24
25 public:
26     vector<vector<T>> v;
27     Matrix(int n, int m, int identity) {
28         v = vector<vector<T>>(n, vector<T>(m, 0));
29         if(identity)
30             for(int i = 0, k = min(n, m); i < k; ++i)
31                 v[i][i] = 1;
32     }
33     Matrix(Matrix &b) { v = b.v; }
34     void in(int l = 0, int m = -1, int u = 0, int n = -1) {
35         if(n < 0) n = v.size();
36         if(m < 0) m = v[0].size();
37         for(int i = u; i < n; ++i)
38             for(int j = l; j < m; ++j) scanf("%lld", &v[i][j]);
39     }
40     Matrix(int n, int m) {
41         v = vector<vector<T>>(n, vector<T>(m, 0));
42         in();
43     }
44     void out(int l = 0, int m = -1, int u = 0, int n = -1) {
45         if(n < 0) n = v.size();
46         if(m < 0) m = v[0].size();
47         for(int i = u; i < n; ++i)
48             for(int j = l; j < m; ++j)
49                 printf("%lld%c", v[i][j], " \n"[j == m - 1]);
50     }
51     Matrix operator=(Matrix &b) {
52         v = b.v;
53         return *this;
54     }
55     Matrix operator+(Matrix &b) {
56         Matrix ans(*this);
57         int n = v.size(), m = v[0].size();
58         for(int i = 0; i < n; ++i)
59             for(int j = 0; j < m; ++j) {
60                 ans.v[i][j] += b.v[i][j];
61                 if(MOD) {
62                     if(ans.v[i][j] < 0)
63                         ans.v[i][j] =
64                             (ans.v[i][j] % MOD + MOD) % MOD;
65                     if(ans.v[i][j] >= MOD) ans.v[i][j] %= MOD;
66                 }
67             }
68         return ans;
69     }
70     Matrix operator*(T x) {
71         Matrix ans(*this);
72         int n = v.size(), m = v[0].size();
73         for(int i = 0; i < n; ++i)
74             for(int j = 0; j < m; ++j) {
75                 ans.v[i][j] *= x;
76                 if(MOD) {
77                     if(ans.v[i][j] < 0)
78                         ans.v[i][j] =
79                             (ans.v[i][j] % MOD + MOD) % MOD;
80                     if(ans.v[i][j] >= MOD) ans.v[i][j] %= MOD;
81                 }
82             }
83         return ans;
84     }
85     Matrix operator-(Matrix &b) {
86         Matrix ans(*this);
87         int n = v.size(), m = v[0].size();
88         for(int i = 0; i < n; ++i)
89             for(int j = 0; j < m; ++j) {
90                 ans.v[i][j] -= b.v[i][j];
91                 if(MOD) {
92                     if(ans.v[i][j] < 0)
93                         ans.v[i][j] =
94                             (ans.v[i][j] % MOD + MOD) % MOD;
95                     if(ans.v[i][j] >= MOD) ans.v[i][j] %= MOD;
96                 }
97             }
98         return ans;
99     }
100     Matrix operator-(T x) {
101         Matrix ans(*this);
102         int n = v.size(), m = v[0].size();
103         for(int i = 0; i < n; ++i)
104             for(int j = 0; j < m; ++j) {
105                 ans.v[i][j] -= x;
106                 if(MOD) {
107                     if(ans.v[i][j] < 0)
108                         ans.v[i][j] =
109                             (ans.v[i][j] % MOD + MOD) % MOD;
110                     if(ans.v[i][j] >= MOD) ans.v[i][j] %= MOD;
111                 }
112             }
113         return ans;
114     }
115     Matrix operator+=(Matrix &b) {
116         int n = v.size(), m = v[0].size();
117         for(int i = 0; i < n; ++i)
118             for(int j = 0; j < m; ++j) {
119                 v[i][j] += b.v[i][j];
120                 if(MOD) {
121                     if(v[i][j] < 0)
122                         v[i][j] = (v[i][j] % MOD + MOD) % MOD;
123                     if(v[i][j] >= MOD) v[i][j] %= MOD;
124                 }
125             }
126         return *this;
127     }
128     Matrix operator*(T x) {
129         int n = v.size(), m = v[0].size();
130         for(int i = 0; i < n; ++i)
131             for(int j = 0; j < m; ++j) {
132                 v[i][j] *= x;
133                 if(MOD) {
134                     if(v[i][j] < 0)
135                         v[i][j] = (v[i][j] % MOD + MOD) % MOD;
136                     if(v[i][j] >= MOD) v[i][j] %= MOD;
137                 }
138             }
139         return *this;
140     }
141     Matrix operator-(Matrix &b) {
142         int n = v.size(), m = v[0].size();
143         for(int i = 0; i < n; ++i)
144             for(int j = 0; j < m; ++j) {
145                 v[i][j] -= b.v[i][j];
146                 if(MOD) {
147                     if(v[i][j] < 0)
148                         v[i][j] = (v[i][j] % MOD + MOD) % MOD;
149                     if(v[i][j] >= MOD) v[i][j] %= MOD;
150                 }
151             }
152         return *this;
153     }
154     Matrix operator-(T x) {
155         int n = v.size(), m = v[0].size();
156         for(int i = 0; i < n; ++i)
157             for(int j = 0; j < m; ++j) {
158                 v[i][j] -= x;
159                 if(MOD) {
160                     if(v[i][j] < 0)
161                         v[i][j] = (v[i][j] % MOD + MOD) % MOD;
162                     if(v[i][j] >= MOD) v[i][j] %= MOD;
163                 }
164             }
165         return *this;
166     }
167     Matrix operator*(Matrix &b) {
168         int n = v.size();
169         int p = b.v.size();
170         int m = b.v[0].size();
171         Matrix ans(n, m, 0);
172         for(int i = 0; i < n; ++i)
173             for(int k = 0; k < p; ++k)
174                 for(int j = 0; j < m; ++j) {
175                     ans.v[i][j] += v[i][k] * b.v[k][j];
176                     if(MOD) {
177                         if(ans.v[i][j] < 0)
178                             ans.v[i][j] =
179                                 (ans.v[i][j] % MOD + MOD) % MOD;
180                         if(ans.v[i][j] >= MOD)
181                             ans.v[i][j] %= MOD;
182                     }
183                 }
184         return ans;
185     }
186     Matrix operator*(T x) {
187         Matrix ans(*this);
188         int n = v.size(), m = v[0].size();
189         for(int i = 0; i < n; ++i)

```

```

191     for(int j = 0; j < m; ++j) {
192         ans.v[i][j] *= x;
193         if(MOD) {
194             if(ans.v[i][j] < 0)
195                 ans.v[i][j] =
196                     (ans.v[i][j] % MOD + MOD) % MOD;
197             if(ans.v[i][j] >= MOD) ans.v[i][j] %= MOD;
198         }
199     }
200     return ans;
201 }
202 Matrix operator*(Matrix &b) {
203     int n = v.size();
204     int p = b.v.size();
205     int m = b.v[0].size();
206     Matrix ans(n, m, 0);
207     for(int i = 0; i < n; ++i)
208         for(int k = 0; k < p; ++k)
209             for(int j = 0; j < m; ++j) {
210                 ans.v[i][j] += v[i][k] * b.v[k][j];
211                 if(MOD) {
212                     if(ans.v[i][j] < 0)
213                         ans.v[i][j] =
214                             (ans.v[i][j] % MOD + MOD) % MOD;
215                     if(ans.v[i][j] >= MOD)
216                         ans.v[i][j] %= MOD;
217                 }
218             }
219     v = ans.v;
220     return *this;
221 }
222 Matrix operator*(T x) {
223     int n = v.size(), m = v[0].size();
224     for(int i = 0; i < n; ++i)
225         for(int j = 0; j < m; ++j) {
226             v[i][j] *= x;
227             if(MOD) {
228                 if(v[i][j] < 0)
229                     v[i][j] = (v[i][j] % MOD + MOD) % MOD;
230                 if(v[i][j] >= MOD) v[i][j] %= MOD;
231             }
232         }
233     return *this;
234 }
235 Matrix operator/(T x) {
236     Matrix ans(*this);
237     int n = v.size(), m = v[0].size();
238     for(int i = 0; i < n; ++i)
239         for(int j = 0; j < m; ++j) {
240             if(MOD) {
241                 ans.v[i][j] = modeq(x, (T)1, (T)MOD);
242                 if(ans.v[i][j] < 0)
243                     ans.v[i][j] =
244                         (ans.v[i][j] % MOD + MOD) % MOD;
245                 if(ans.v[i][j] >= MOD) ans.v[i][j] %= MOD;
246             } else
247                 ans.v[i][j] /= x;
248         }
249     return ans;
250 }
251 Matrix operator/(T x) {
252     int n = v.size(), m = v[0].size();
253     for(int i = 0; i < n; ++i)
254         for(int j = 0; j < m; ++j) {
255             if(MOD) {
256                 v[i][j] = modeq(x, (T)1, (T)MOD);
257                 if(v[i][j] < 0)
258                     v[i][j] = (v[i][j] % MOD + MOD) % MOD;
259                 if(v[i][j] >= MOD) v[i][j] %= MOD;
260             } else
261                 v[i][j] /= x;
262         }
263     return *this;
264 }
265 Matrix operator%=(T p) {
266     int n = v.size(), m = v[0].size();
267     for(int i = 0; i < n; ++i)
268         for(int j = 0; j < m; ++j)
269             if(v[i][j] >= p) v[i][j] %= p;
270     return *this;
271 }
272 void gaussian() {
273     int curi = 0;
274     int n = v.size();
275     int m = v[0].size();
276     for(int j = 0; j < m; j++) {
277         int i;
278         for(i = curi; i < n; i++) {
279             if(MOD) {
280                 v[i][j] %= MOD;
281             }
282             if(v[i][j]) {
283                 break;

```

```

283     }
284 }
285 if(i >= n) {
286     continue;
287 }
288 if(v[i][j] == 0) continue;
289 for(int k = 0; k < m; k++) {
290     swap(v[i][k], v[curi][k]);
291 }
292 for(int k = m - 1; k >= j; k--) {
293     if(MOD) {
294         v[curi][k] =
295             modeq(v[curi][k], (T)1, (T)MOD);
296         v[curi][k] = (v[curi][k] % MOD + MOD) % MOD;
297     } else
298         v[curi][k] /= v[curi][j];
299 }
300 for(int i = 0; i < n; ++i) {
301     if(i != curi) {
302         for(int k = m - 1; k >= j; k--) {
303             v[i][k] -= v[curi][k] * v[i][j];
304             if(MOD) {
305                 v[i][k] =
306                     (v[i][k] % MOD + MOD) % MOD;
307             }
308         }
309     }
310 }
311 curi++;
312 }
313 }
314 };

```

2.10. MillerRabin.cpp

```

1 #define uLL __uint128_t
2 template <class T, class POW>
3 void fastpow(T x, POW n, POW p, T &ans) {
4     for(; n >= 1; n--) {
5         if(n & 1) {
6             ans *= x;
7             ans %= p;
8         }
9         x *= x;
10        x %= p;
11    }
12 }
13 /* 輸入 x,n,p,ans 會將 ans 修改為 x^n%p
14    對整數/矩陣/不要求精度的浮點 皆有效
15    模板第一個型別是 x,ans 第二個是 n,p(應該放 LL 或 __int128)*/
16 uLL pri[7] = {2, 325, 9375, 28178,
17              450775, 9780504, 1795265022}; /*2^64*/
18 // int p[3]={2,7,61};/*2^32*/
19 bool check(const uLL x, const uLL p) {
20     uLL d = x - 1, ans = 1;
21     fastpow(p, d, x, ans);
22     if(ans != 1) return 1;
23     for(; !(d & 1); d >>= 1) {
24         ans = 1;
25         fastpow(p, d, x, ans);
26         if(ans == x - 1)
27             return 0;
28         else if(ans != 1)
29             return 1;
30     }
31     return 0;
32 }
33 bool miller_rabin(const uLL x) {
34     if(x == 1) return 0;
35     for(auto e : pri) {
36         if(e >= x) return 1;
37         if(check(x, e)) return 0;
38     }
39     return 1;
40 }
41 }

```

2.11. Mu.cpp

```

1 vector<int> prime;
2 bitset<1000005> vis;
3 int n;
4 int mu[1000005];
5 void init() {
6     for(int i = 2; i <= n; i++) {
7         if(!vis[i]) {
8             prime.push_back(i);
9             mu[i] = -1;
10        }
11    }
12    for(int p : prime) {
13        if(i * p > n) break;

```

```

15     vis[i * p] = 1;
16     if(i % p == 0) {
17         mu[i * p] = 0;
18         break;
19     } else {
20         mu[i * p] = mu[i] * mu[p];
21     }
22 }
23 }

```

2.12. NTT.cpp

```

1  #define ll long long
2  using namespace std;
3
4  const int MAXN = 1000005;
5  const int MOD = 998244353, G = 3;
6  int rev[MAXN * 3];
7
8  int qpow(int x, int y) {
9      int ret = 1;
10     while(y) {
11         if(y & 1) {
12             ret *= x;
13             ret %= MOD;
14         }
15         x *= x;
16         x %= MOD;
17         y >>= 1;
18     }
19     return ret;
20 }
21
22 void ntt(int F[], int N, int sgn) {
23     int bit = __lg(N);
24     for(int i = 0; i < N; ++i) {
25         rev[i] = (rev[i >> 1] >> 1) | ((i & 1) << (bit - 1));
26         if(i < rev[i]) swap(F[i], F[rev[i]]);
27     }
28     for(int l = 1, t = 1; l < N; l <= 1, t++) {
29         int step = qpow(G, ((MOD - 1) >> t) * sgn + MOD - 1);
30         for(int i = 0; i < N; i += l << 1) {
31             for(int k = i, cur = 1; k < i + l; ++k) {
32                 int g = F[k], h = (ll)F[k + l] * cur % MOD;
33                 F[k] = (g + h) % MOD;
34                 F[k + l] = ((g - h) % MOD + MOD) % MOD;
35                 cur = (ll)cur * step % MOD;
36             }
37         }
38     }
39     if(sgn == -1) {
40         int invN = qpow(N, MOD - 2);
41         for(int i = 0; i < N; ++i) F[i] = (ll)F[i] * invN % MOD;
42     }
43 }

```

2.13. PollardRho.cpp

```

1  using namespace std;
2  #define LL long long
3  #define uLL __uint128_t
4  #define sub(a, b) ((a) < (b) ? (b) - (a) : (a) - (b))
5  template <class T, class POW>
6  void fastpow(T x, POW n, POW p, T &ans) {
7      for(; n; n >>= 1) {
8          if(n & 1) {
9              ans *= x;
10             ans %= p;
11         }
12         x *= x;
13         x %= p;
14     }
15 }
16
17 /*input x, n, p, ans, will modify ans to x ^ n % p
18 the first is x, ans and the second is n, p (LL or __uint128)
19 */
20 uLL pri[7] = {2, 325, 9375, 28178,
21              450775, 9780504, 1795265022}; /*2^64*/
22 // int p[3]={2,7,61};/*2^32*/
23 bool check(const uLL x, const uLL p) {
24     uLL d = x - 1, ans = 1;
25     fastpow(p, d, x, ans);
26     if(ans != 1) return 1;
27     for(; !(d & 1);) {
28         d >>= 1;
29         ans = 1;
30         fastpow(p, d, x, ans);
31         if(ans == x - 1)
32             return 0;
33         else if(ans != 1)
34             return 1;
35     }
36 }

```

```

35     }
36     return 0;
37 }
38 bool miller_rabin(const uLL x) {
39     if(x == 1) return 0;
40     for(auto e : pri) {
41         if(e >= x) return 1;
42         if(check(x, e)) return 0;
43     }
44     return 1;
45 }
46 template <class T> T gcd(T a, T b) {
47     if(!a) return b;
48     if(!b) return a;
49     if(a & b & 1) return gcd(sub(a, b), min(a, b));
50     if(a & 1) return gcd(a, b >> 1);
51     if(b & 1) return gcd(a >> 1, b);
52     return gcd(a >> 1, b >> 1) << 1;
53 }
54 /*gcd(a,b) denote gcd(a, 0) = a*/
55 mt19937 rnd(time(0));
56 template <class T> T f(T x, T c, T mod) {
57     return (((uLL)x) * x % mod + c) % mod;
58 }
59 template <class T> T rho(T n) {
60     T mod = n, x = rnd() % mod, c = rnd() % (mod - 1) + 1,
61     p = 1;
62     for(T i = 2, j = 2, d = x; ++i) {
63         x = f(x, c, mod);
64         p = ((uLL)p) * sub(x, d) % mod;
65         if(i % 127 == 0 && gcd(p, n) != 1) return gcd(p, n);
66         if(i == j) {
67             j <= 1, d = x;
68             if(gcd(p, n) != 1) return gcd(p, n);
69         }
70     }
71 }
72 template <class T> T pollard_rho(T n) {
73     if(miller_rabin(n)) return n;
74     T p = n;
75     while(p == n) p = rho(n);
76     return max(pollard_rho(p), pollard_rho(n / p));
77 }
78 int main() {
79     LL t, n, ans;
80     for(cin >> t; t--;) {
81         cin >> n;
82         ans = pollard_rho(n);
83         if(ans == n)
84             puts("Prime");
85         else
86             printf("%lld\n", ans);
87     }
88 }

```

2.14. XorBasis.cpp

```

1  #pragma GCC optimize(
2      "Ofast,fast-math,unroll-loops,no-stack-protector")
3
4  using namespace std;
5  #define ll long long
6  #define V vector
7  #define pb push_back
8  #define all(x) x.begin(), x.end()
9  V<ll> v;
10 ll f(ll k, ll now = 0, ll p = v.size() - 1, ll ans = 0) {
11     if(k >= 1 << p) {
12         k -= 1 << p;
13         ans = max(ans, ans ^ v[now]);
14     } else
15         ans = min(ans, ans ^ v[now]);
16     if(!p) return ans;
17     return f(k, now + 1, p - 1, ans);
18 }
19 int main() {
20     ios::sync_with_stdio(0);
21     cin.tie(0);
22     cout.tie(0);
23     ll n, k;
24     cin >> n >> k;
25     for(ll x, i = 0; i < n; ++i) {
26         cin >> x;
27         for(ll &e : v) x = min(x, x ^ e);
28         if(x) v.pb(x);
29     }
30     sort(all(v), greater<ll>());
31     ll t = n - v.size(), a = k >> t,
32     b = k & ((1 << min(t, 20LL)) - 1), i = 0;
33     for(; a--; ++i)
34         for(ll j = 1 << t, p = f(i); j--;) cout << p << " ";
35     for(i = f(i); b--;) cout << i << " ";
36 }

```


3. String

3.1. Booth.cpp

```
1 #define V vector
2 string booth(string s) {
3     s += s;
4     int n = s.size(), k = 0;
5     V<int> f(n, -1);
6     for(int i = 1; i < n; ++i) {
7         int j = f[i - k - 1];
8         for(; j >= 0 && s[j + k + 1] != s[i]; j = f[j])
9             if(s[i] < s[j + k + 1]) k = i - j - 1;
10            if(s[i] != s[j + k + 1]) {
11                if(s[i] < s[k]) k = i;
12                f[i - k] = -1;
13            } else
14                f[i - k] = j + 1;
15        }
16    return s.substr(k, s.size() >> 1);
17 }
//給出循環排列後最小字典序的解
```

3.2. KMP.cpp

```
1 string s, t;
2 int pmt[1000005];
3
4 void init() {
5     for(int i = 1, j = 0; i < t.size(); i++) {
6         while(j && t[j] ^ t[i]) {
7             j = pmt[j - 1];
8         }
9         if(t[j] == t[i]) j++;
10        pmt[i] = j;
11    }
12 }
13
14 int kmp(string s) {
15     int ret = 0;
16     for(int i = 0, j = 0; i < s.size(); i++) {
17         while(j && s[i] ^ t[j]) {
18             j = pmt[j - 1];
19         }
20         if(s[i] == t[j]) {
21             j++;
22         }
23         if(j == t.size()) {
24             ret++;
25             j = pmt[j - 1];
26         }
27     }
28     return ret;
29 }
```

3.3. LongestPalindrome.cpp

```
1 #define int long long
2 using namespace std;
3
4 string s;
5 string t;
6 int n;
7 int d[2000005];
8 int ans = 0;
9
10 signed main() {
11     cin >> t;
12     n = t.size();
13     for(int i = 0; i < 2 * n + 1; i++) {
14         if(i & 1) {
15             s += '0';
16         } else {
17             s += t[i / 2];
18         }
19     }
20     n = s.size();
21     d[0] = 1;
22     for(int i = 0, l = 0, r = 0; i < n; i++) {
23         if(i > r) {
24             d[i] = 1;
25             bool a = i + d[i] < n;
26             bool b = i - d[i] >= 0;
27             bool c = (s[i + d[i]] == s[i - d[i]]);
28             while (a && b && c) {
29                 d[i]++;
30                 a = i + d[i] < n;
31                 b = i - d[i] >= 0;
32                 c = (s[i + d[i]] == s[i - d[i]]);
33             }
34             l = i - d[i] + 1;
35         }
```

```

36         r = i + d[i] - 1;
37     } else {
38         int j = l + r - i;
39         if(j - d[j] + 1 > l) {
40             d[i] = d[j];
41         } else {
42             d[i] = r - i + 1;
43             a = i + d[i] < n;
44             b = i - d[i] >= 0;
45             c = (s[i + d[i]] == s[i - d[i]]);
46             while(a && b && c) {
47                 d[i]++;
48                 a = i + d[i] < n;
49                 b = i - d[i] >= 0;
50                 c = (s[i + d[i]] == s[i - d[i]]);
51             }
52             l = i - d[i] + 1;
53             r = i + d[i] - 1;
54         }
55     }
56     // cout << d[i] << " ";
57     if(d[i] > d[ans]) {
58         ans = i;
59     }
60 }
61 for(int i = ans - d[ans] + 1; i < ans + d[ans]; i++) {
62     if(s[i] ^ '0') {
63         cout << s[i];
64     }
65 }
```

3.4. Z.cpp

```
1 #define int long long
2 using namespace std;
3
4 string s, t;
5 int ans = 0;
6
7 int z[2000005];
8
9 signed main() {
10     ios::sync_with_stdio(0);
11     cin.tie(0);
12     cout.tie(0);
13     cin >> s >> t;
14     s = t + '0' + s;
15     int n, m;
16     n = s.size();
17     m = t.size();
18     for(int i = 0, l = 0, r = 0; i < n; i++) {
19         if(z[i - l] < r - i + 1) {
20             z[i] = z[i - l];
21         } else {
22             z[i] = max(r - i + 1, (int)0);
23             while(i + z[i] < n && s[i + z[i]] == s[z[i]]) {
24                 z[i]++;
25             }
26             l = i;
27             r = i + z[i] - 1;
28             if(z[i] == m) {
29                 ans++;
30             }
31         }
32     }
33     cout << ans;
34 }
```

4. Graph

4.1. 2-SAT(CSES Planets Cycles).cpp

```
1 #define int long long
2 using namespace std;
3
4 int n, m;
5 vector<int> v[200005];
6 int d[200005];
7 int low[200005];
8 int cnt = 0;
9 int now = 0;
10 int scc[200005];
11 stack<int> s;
12 int op[200005];
13 vector<int> v2[200005];
14 int ind[200005];
15 queue<int> q;
16 int ans[200005];
```

```

19 int no(int x) {
20     if(x > m) return x - m;
21     return x + m;
22 }
23
24 void dfs(int x) {
25     d[x] = low[x] = ++cnt;
26     s.push(x);
27     for(int i : v[x]) {
28         if(scc[i]) continue;
29         if(d[i]) {
30             low[x] = min(low[x], d[i]);
31         } else {
32             dfs(i);
33             low[x] = min(low[x], low[i]);
34         }
35     }
36     if(d[x] == low[x]) {
37         now++;
38         while(!s.empty()) {
39             int k = s.top();
40             s.pop();
41             scc[k] = now;
42             if(k == x) break;
43         }
44     }
45 }
46
47 signed main() {
48     ios::sync_with_stdio(0);
49     cin.tie(0);
50     cout.tie(0);
51     cin >> n >> m;
52     while(n--) {
53         char a, b;
54         int x, y;
55         cin >> a >> x >> b >> y;
56         if(a == '-') x = no(x);
57         if(b == '-') y = no(y);
58         v[no(x)].push_back(y);
59         v[no(y)].push_back(x);
60     }
61     for(int i = 1; i <= 2 * m; i++) {
62         if(!d[i]) {
63             dfs(i);
64         }
65     }
66     for(int i = 1; i <= m; i++) {
67         if(scc[i] ^ scc[i + m]) {
68             op[scc[i]] = scc[i + m];
69             op[scc[i + m]] = scc[i];
70         } else {
71             cout << "IMPOSSIBLE";
72             exit(0);
73         }
74     }
75     for(int i = 1; i <= 2 * m; i++) {
76         for(int j : v[i]) {
77             if(scc[i] ^ scc[j]) {
78                 v2[scc[j]].push_back(scc[i]);
79                 ind[scc[i]]++;
80             }
81         }
82     }
83     for(int i = 1; i <= now; i++) {
84         if(!ind[i]) {
85             q.push(i);
86         }
87     }
88     while(!q.empty()) {
89         int k = q.front();
90         q.pop();
91         if(!ans[k]) {
92             ans[k] = 1;
93             ans[op[k]] = 2;
94         }
95         for(int i : v2[k]) {
96             ind[i]--;
97             if(!ind[i]) {
98                 q.push(i);
99             }
100         }
101     }
102     for(int i = 1; i <= m; i++) {
103         if(ans[scc[i]] == 1) {
104             cout << "+ ";
105         } else {
106             cout << "- ";
107         }
108     }
109 }

```

4.2. Dijkstra.cpp

```

1 vector<pair<int, int>> v[100005], v2[100005];
2 vector<edge> es;
3 int dis1[100005];
4 int dis2[100005];
5 bitset<100005> vis1, vis2;
6
7 void dijkstra(int x, int *dis, vector<pair<int, int>> *v,
8               bitset<100005> &vis) {
9     priority_queue<pair<int, int>, vector<pair<int, int>>,
10                   greater<pair<int, int>>>
11         pq;
12     memset(dis, 0x3f, sizeof(dis1));
13     vis.reset();
14     dis[x] = 0;
15     pq.push({0, x});
16     while(!pq.empty()) {
17         pair<int, int> now = pq.top();
18         pq.pop();
19         if(vis[now.second]) continue;
20         vis[now.second] = 1;
21         for(auto [i, w] : v[now.second]) {
22             if(vis[i]) continue;
23             if(dis[now.second] + w < dis[i]) {
24                 dis[i] = dis[now.second] + w;
25                 pq.push({dis[i], i});
26             }
27         }
28     }
29 }

```

4.3. Dinic.cpp

```

1 using namespace std;
2 #define ll long long
3 const ll inf = 8e18;
4 #define N 505
5 #define pb push_back
6 struct pp {
7     int from, to;
8     ll flow;
9 };
10 int t, lvl[N], p[N];
11 vector<int> g[N];
12 vector<pp> edge;
13 int bfs(int s) {
14     queue<int> q;
15     for(q.push(s), lvl[s] = 1; !q.empty(); q.pop()) {
16         int u = q.front();
17         for(int e : g[u]) {
18             int v = edge[e].to;
19             if(lvl[v] || !edge[e].flow) continue;
20             lvl[v] = lvl[u] + 1;
21             q.push(v);
22         }
23     }
24     return lvl[t];
25 }
26 ll dfs(int u, ll f = inf) {
27     if(u == t || !f) return f;
28     ll ans = 0;
29     for(int &i = p[u]; i < g[u].size(); ++i) {
30         pp &e = edge[g[u][i]], &b = edge[g[u][i] ^ 1];
31         if(lvl[e.to] == lvl[u] + 1) {
32             ll c = dfs(e.to, min(e.flow, f));
33             e.flow -= c;
34             b.flow += c;
35             f -= c;
36             ans += c;
37         }
38     }
39     return ans;
40 }
41 ll dinic(int s) {
42     ll ans = 0;
43     for(; bfs(s); memset(lvl, 0, sizeof lvl))
44         for(ll k; k = (memset(p, 0, sizeof(p)), dfs(s));)
45             ans += k;
46     return ans;
47 }
48 int main() {
49     ios::sync_with_stdio(0);
50     cin.tie(0);
51     cout.tie(0);
52     int n, m, cnt = 0;
53     for(cin >> n >> m; m--;) {
54         int u, v;
55         ll f;
56         cin >> u >> v >> f;
57         g[u].pb(cnt++);
58         g[v].pb(cnt++);
59     }

```

```

    edge.pb({u, v, f});
    edge.pb({v, u, 0});
}
t = n;
cout << dinic(1);
}

```

4.4. MaximumFlow.cpp

```

1 #define int long long
3 using namespace std;

5 int n, m;
vector<int> v[1005];
int head[1005];
int c[1005][1005];
int lv[1005];
int ans = 0;

11 bool bfs() {
13     memset(head, 0, sizeof(head));
14     memset(lv, 0, sizeof(lv));
15     queue<int> q;
16     q.push(1);
17     while(!q.empty()) {
18         int now = q.front();
19         q.pop();
20         if(now == n) continue;
21         for(int i : v[now]) {
22             if(i != 1 && c[now][i] && !lv[i]) {
23                 lv[i] = lv[now] + 1;
24                 q.push(i);
25             }
26         }
27     }
28     return lv[n];
29 }

31 int dfs(int x, int flow) {
32     int ret = 0;
33     if(x == n) return flow;
34     for(int i = head[x]; i < v[x].size(); i++) {
35         int y = v[x][i];
36         head[x] = y;
37         if(c[x][y] && lv[y] == lv[x] + 1) {
38             int d = dfs(y, min(flow, c[x][y]));
39             flow -= d;
40             c[x][y] -= d;
41             c[y][x] += d;
42             ret += d;
43         }
44     }
45     return ret;
46 }

47 signed main() {
48     cin >> n >> m;
49     while(m--) {
50         int x, y, z;
51         cin >> x >> y >> z;
52         if(c[x][y] || c[y][x]) {
53             c[x][y] += z;
54             continue;
55         }
56         v[x].push_back(y);
57         v[y].push_back(x);
58         c[x][y] = z;
59     }
60     while(bfs()) {
61         ans += dfs(1, INT_MAX);
62     }
63     cout << ans;
64 }

```

4.5. SCC.cpp

```

1 int n, m;
vector<int> v[100005];
int d[100005];
int low[100005];
int cnt = 0;
stack<int> s;
int scc[100005];
int now = 0;

9 void dfs(int x) {
11     d[x] = low[x] = ++cnt;
12     s.push(x);
13     for(int i : v[x]) {
14         if(scc[i]) continue;
15         if(d[i]) {
16             low[x] = min(low[x], d[i]);

```

```

17     } else {
18         dfs(i);
19         low[x] = min(low[x], low[i]);
20     }
21 }
22 if(d[x] == low[x]) {
23     now++;
24     while(!s.empty()) {
25         int k = s.top();
26         s.pop();
27         scc[k] = now;
28         if(k == x) break;
29     }
30 }
31 }

```

4.6. VBCC.cpp

```

1 using namespace std;
3 #define pb push_back
4 #define pii pair<int, int>
5 #define N 100005
vector<int> adj[N], bcc[N];
stack<int> st;
int dfn[N], low[N], tag, bc, root;
bitset<N> ap;
void dfs(int now, int par = -1) {
11     st.push(now);
12     low[now] = dfn[now] = ++tag;
13     int f = 0;
14     for(int e : adj[now] | views::reverse) {
15         if(e == par) continue;
16         if(!dfn[e]) {
17             dfs(e, now), low[now] = min(low[now], low[e]);
18             if(low[e] >= dfn[now]) {
19                 if(++f > 1 || now != root) ap[now] = 1;
20                 ++bc;
21                 for(; st.top() != now; st.pop())
22                     bcc[bc].pb(st.top());
23                 bcc[bc].pb(now);
24             }
25         } else {
26             low[now] = min(low[now], dfn[e]);
27         }
28     }
29 int main() {
30     int n, m, u, v;
31     cin >> n >> m;
32     vector<pii> g(m);
33     for(auto &[u, v] : g)
34         cin >> u >> v, adj[u].pb(v), adj[v].pb(u);
35     for(root = 1; root <= n; ++root)
36         if(!dfn[root]) dfs(root);
37     int ans = 0;
38     for(int i : views::iota(1) | views::take(n))
39         if(ap[i]) ++ans;
40     cout << ans << "\n";
41     for(int i : views::iota(1) | views::take(n))
42         if(ap[i]) cout << i << " ";
43 }

```

4.7. one-degree-cycle(CSES Planets Cycles).cpp

```

1 #define int long long
3 using namespace std;

5 int n, q;
int a[200005];
int r[200005];
int d[200005];
int cycle[200005];
int len[200005];
int cnt = 0;
vector<int> v[200005];
bitset<200005> vis1;
bitset<200005> vis2;

15 void findcycle(int x) {
17     while(!vis1[x]) {
18         vis1[x] = 1;
19         x = a[x];
20     }
21     cnt++;
22     cycle[x] = cnt;
23     r[x] = 0;
24     len[cnt] = 1;
25     int temp = a[x];
26     while(temp ^ x) {
27         r[temp] = len[cnt];
28         len[cnt]++;
29         cycle[temp] = cnt;

```

```

    temp = a[temp];
}
}
33 void dfs(int x) {
35     if(vis2[x]) return;
    vis2[x] = 1;
37     for(int i : v[x]) {
        dfs(i);
    }
39 }
41 void dfs2(int x) {
43     if(cycle[x] || d[x]) return;
    dfs2(a[x]);
45     d[x] = d[a[x]] + 1;
    r[x] = r[a[x]];
    cycle[x] = cycle[a[x]];
47 }
49 signed main() {
51     ios::sync_with_stdio(0);
    cin.tie(0);
53     cout.tie(0);
    cin >> n;
55     for(int i = 1; i <= n; i++) {
        cin >> a[i];
        v[i].push_back(a[i]);
        v[a[i]].push_back(i);
    }
57     for(int i = 1; i <= n; i++) {
        if(!vis2[i]) {
            findcycle(i);
            dfs(i);
        }
    }
61     for(int i = 1; i <= n; i++) {
        if(!cycle[i] && !r[i]) {
            dfs2(i);
        }
    }
63     for(int i = 1; i <= n; i++) {
        if(!cycle[i] && !r[i]) {
            dfs2(i);
        }
    }
65     for(int i = 1; i <= n; i++) {
        if(!cycle[i] && !r[i]) {
            dfs2(i);
        }
    }
67     for(int i = 1; i <= n; i++) {
        cout << d[i] + len[cycle[i]] << " ";
    }
71 }
73 }

```

5. DP

5.1. CHO.cpp

```

1 struct line {
    int a, b;
    int y(int x) { return a * x + b; }
};
3
5 struct CHO {
7     deque<line> dq;
    int intersect(line x, line y) {
9         int d1 = x.b - y.b;
        int d2 = y.a - x.a;
        return d1 / d2;
    }
11     bool check(line x, line y, line z) {
        int I12 = intersect(x, y);
        int I23 = intersect(y, z);
        return I12 < I23;
    }
13     void insert(int a, int b) {
        if(!dq.empty() && a == dq.back().a) return;
        while(dq.size() >= 2 &&
21             !check(dq[dq.size() - 2], dq[dq.size() - 1],
                {a, b})) {
            dq.pop_back();
        }
        dq.push_back({a, b});
    }
23     void update(int x) {
        while(dq.size() >= 2 && dq[0].y(x) >= dq[1].y(x)) {
25             dq.pop_front();
        }
    }
27     int query(int x) {
        update(x);
        return dq.front().y(x);
    }
31 }
33 }
35 }

```

5.2. Li-Chao-SegmentTree.cpp

```

1 struct line {
    int a, b = 1000000000000000000;

```

```

3     int y(int x) { return a * x + b; }
};
5 line tree[4000005];
7 int n, x;
8 int s[200005];
9 int f[200005];
10 int dp[200005];
11 void update(line ins, int l = 1, int r = 1e6, int index = 1) {
13     if(l == r) {
        if(ins.y(l) < tree[index].y(l)) {
            tree[index] = ins;
        }
        return;
    }
15     int mid = (l + r) >> 1;
    if(tree[index].a < ins.a) swap(tree[index], ins);
    if(tree[index].y(mid) > ins.y(mid)) {
        swap(tree[index], ins);
        update(ins, l, mid, index << 1);
    } else {
        update(ins, mid + 1, r, index << 1 | 1);
    }
27 }
29 int query(int x, int l = 1, int r = 1000000, int index = 1) {
    int cur = tree[index].y(x);
    if(l == r) {
        return cur;
    }
    int mid = (l + r) >> 1;
    if(x <= mid) {
        return min(cur, query(x, l, mid, index << 1));
    } else {
        return min(cur, query(x, mid + 1, r, index << 1 | 1));
    }
39 }

```

5.3. SOSDP.cpp

```

1 for(int i = 0; i < 20; ++i)
    for(int j = i; j < N; ++j)
        if(j >> i & 1) dp[j] += dp[j ^ (1 << i)]; // subset
3 for(int i = 0; i < 20; ++i)
    for(int j = 0; j < N; ++j)
        if(!(j >> i & 1)) dp2[j] += dp2[j | (1 << i)]; // superset
7

```

6. Geometry

6.1. 164253Version.cpp

```

1 using namespace std;
2 #define ll long long
3 #define pb push_back
4 #define pll pair<int, int>
5 #define pdd pair<double, double>
6 #define pll pair<ll, ll>
7 #define F first
8 #define S second
9 #define eps 1e-6
10 int sign(double x) {
    return fabs(x) < eps ? 0 : x > 0 ? 1 : -1;
}
12 int sign(ll x) { return !x ? 0 : x > 0 ? 1 : -1; }
13 template <typename T1, typename T2>
14 istream &operator>>(istream &s, pair<T1, T2> &p) {
    auto &a, &b = p;
    s >> a >> b;
    return s;
}
16 template <typename T1, typename T2>
17 ostream &operator<<(ostream &s, const pair<T1, T2> &p) {
    auto &a, &b = p;
    s << a << " " << b;
    return s;
}
19 pll operator+(const pll a, const pll b) {
    return {a.F + b.F, a.S + b.S};
}
21 pll operator-(const pll a, const pll b) {
    return {a.F - b.F, a.S - b.S};
}
23 pll operator*(const pll a) { return {-a.F, -a.S}; }
25 pll operator/(const pll a, const pll b) {
    return {(ll)a.F * b.F, (ll)a.S * b.S};
}
27 pdd operator/(const pll a, const double x) {
    return {a.F / x, a.S / x};
}
31 }
33 }
35 }

```

```

41 pdd operator*(const pll a, const double x) {
    return {a.F * x, a.S * x};
}
43 pdd operator*(const double x, const pll a) {
    return {a.F * x, a.S * x};
}
45 //沒有標示幾個 vector 的都是對三個點做事，以第一個點為參考點
47 ll len2(pll p) {
    return (ll)p.F * p.F + (ll)p.S * p.S;
}
49 // 1 vector
double len(pll p) { return sqrt((double)len2(p)); }
51 ll cross(pll a, pll b) {
    return (ll)a.F * b.S - (ll)a.S * b.F;
}
53 // 2 vector
ll cross(pll p1, pll p2, pll p3) {
    return cross(p2 - p1, p3 - p1);
}
55 // (b-a) cross (c-a)
ll dot(pll a, pll b, pll c) {
    return (ll)(b.F - a.F) * (c.F - a.F) +
        (ll)(b.S - a.S) * (c.S - a.S);
}
57 // (b-a) dot (c-a)
ll ori(pll p1, pll p2, pll p3) {
    return sign(cross(p1, p2, p3));
}
63 // normalize to {-1,0,1} (b-a) cross (c-a)
bool btw(pll p1, pll p2, pll p3) {
    return ori(p3, p1, p2) == 0 && dot(p3, p1, p2) <= 0;
}
65 // p3 between p1,p2
bool banana(pll p1, pll p2, pll p3,
    pll p4) { //問兩線段是否香蕉
69 if(btw(p1, p2, p3) || btw(p1, p2, p4) || btw(p3, p4, p1) ||
    btw(p3, p4, p2))
71 return true;
73 return ori(p1, p2, p3) * ori(p1, p2, p4) < 0 &&
    ori(p3, p4, p1) * ori(p3, p4, p2) < 0;
}
75 pdd banana_point(pll p1, pll p2, pll p3,
    pll p4) { //分點，算是無限延伸直線的交點
77 //平行的時候 undefined
79 return cross(p2 - p1, p4 - p1) /
    (double)cross(p2 - p1, p4 - p3) * p3 -
    cross(p2 - p1, p3 - p1) /
81 (double)cross(p2 - p1, p4 - p3) * p4;
}
83 pdd proj(pll p1, pll p2, pll p3) {
    return dot(p1, p2, p3) / (double)len2(p2 - p1) * (p2 - p1);
}
85 double min_dis(pll p1, pll p2,
    pll p3) { // min distance of p3 to segment p1,p2
87 if(dot(p1, p2, p3) < 0 || dot(p2, p1, p3) < 0)
89 return min(len(p3 - p1), len(p3 - p2));
91 return abs(cross(p1, p2, p3)) / len(p2 - p1);
}
93 ll area2(vector<pll> &v) { //傳入一個多邊形照順序的點集
    //起點要出現兩次，回傳兩倍面積
    //注意是兩倍才可以 ll 避免浮點數
95 int n = v.size() - 1;
    ll ans = 0;
97 for(int i = 0; i < n; ++i) ans += cross(v[i], v[i + 1]);
99 return abs(ans);
}
101 int in_polygon(vector<pll> &v,
    pll p) { //傳入多邊形，起點要出現兩次，回傳
    //{-1:in, 0:on, 1:out}
103 int n = v.size() - 1, ans = 1;
    for(int i = 0; i < n; ++i)
105 if(btw(v[i], v[i + 1], p)) return 0;
    for(int i = 0; i < n; ++i)
107 if(banana(v[i], v[i + 1], p, {(ll)2e9 + 7, p.S + 1LL}))
        ans *= -1;
109 //對於任意 p 到 {W, p.S+1}
    //的向量中不會有整數點存在，其中需要滿足 {W, p.S+1}
111 //必須很遠，保證在多邊形外
    return ans;
}
113 void solve() {
115 int n;
    cin >> n;
    vector<pll> v(n);
    for(pll &e : v) cin >> e;
119 v.pb(v[0]);
    ll ans = area2(v) + 2, ans2 = 0;
121 for(int i = 0; i < n; ++i) {
        if(v[i].F == v[i + 1].F)
123 ans2 += abs(v[i].S - v[i + 1].S);
        else if(v[i].S == v[i + 1].S)
125 ans2 += abs(v[i].F - v[i + 1].F);
        else
127 ans2 += gcd(abs(v[i].F - v[i + 1].F),
            abs(v[i].S - v[i + 1].S));
129 }
    cout << (ans - ans2) / 2 << " " << ans2;
131 }
int main() {

```

```

133 int t = 1;
    // cin>>t;
135 for(; t--;) {
        solve();
137 }
}

```

6.2. ConvexHull.cpp

```

1 #define int long long
2 #define fastio
3 ios_base::sync_with_stdio(0);
4 cin.tie(0);
5 cout.tie(0);
6
7 using namespace std;
8
9 template <typename T>
10 pair<T, T> operator-(pair<T, T> a, pair<T, T> b) {
11     return make_pair(a.first - b.first, a.second - b.second);
12 }
13
14 template <typename T> T cross(pair<T, T> a, pair<T, T> b) {
15     return a.first * b.second - a.second * b.first;
16 }
17
18 template <typename T>
19 vector<pair<T, T>> getCH(vector<pair<T, T>> v) {
20     int n = v.size();
21     sort(v.begin(), v.end());
22     vector<pair<T, T>> hull;
23     for(int i = 0; i < 2; i++) {
24         int t = hull.size();
25         for(auto x : v) {
26             while(hull.size() - t >= 2 &&
27                 cross(hull[hull.size() - 1] -
28                     hull[hull.size() - 2],
29                     x - hull[hull.size() - 2]) <= 0)
31                 hull.pop_back();
32             hull.push_back(x);
33         }
34         hull.pop_back();
35         reverse(v.begin(), v.end());
36     }
37     return hull;
}

```

6.3. Inside.cpp

```

1 int inside(point p) {
2     int ans = 0;
3     for(int i = 1; i <= n; i++) {
4         if(onseg(a[i], a[i + 1], {p.x, p.y})) {
5             return -1;
6         }
7         if(intersect({p.x, p.y}, {INF, p.y}, a[i], a[i + 1])) {
8             ans ^= 1;
9         }
10        point temp = a[i].y > a[i + 1].y ? a[i] : a[i + 1];
11        if(temp.y == p.y && temp.x > p.x) {
12            ans ^= 1;
13        }
14    }
15    return ans;
}

```

6.4. Intersect.cpp

```

1 struct point {
2     int x, y;
3     point operator+(point b) { return {x + b.x, y + b.y}; }
4     point operator-(point b) { return {x - b.x, y - b.y}; }
5     int operator*(point b) { return x * b.x + y * b.y; }
6     int operator^(point b) { return x * b.y - y * b.x; }
7 };
8
9 bool onseg(point x, point y, point z) {
10     return ((x - z) ^ (y - z)) == 0 && (x - z) * (y - z) <= 0;
11 }
12
13 int dir(point x, point y) {
14     int k = x ^ y;
15     if(k == 0) return 0;
16     if(k > 0) return 1;
17     return -1;
18 }
19
20 bool intersect(point x, point y, point z, point w) {
21     if(onseg(x, y, z) || onseg(x, y, w)) return 1;
22     if(onseg(z, w, x) || onseg(z, w, y)) return 1;
23     if(dir(y - x, z - x) * dir(y - x, w - x) == -1 &&

```



```

    dir(z - w, x - w) * dir(z - w, y - w) == -1) {
        return 1;
    }
    return 0;
}

```

6.5. MinimumEuclideanDistance.cpp

```

1  #define int long long
3  #define pii pair<int, int>
5  using namespace std;
7
9  int n;
10 vector<pair<int, int>> v;
11 set<pair<int, int>> s;
12 int dd = LONG_LONG_MAX;
13
14 int dis(pii x, pii y) {
15     return (x.first - y.first) * (x.first - y.first) +
16            (x.second - y.second) * (x.second - y.second);
17 }
18
19 signed main() {
20     ios::sync_with_stdio(0);
21     cin.tie(0);
22     cout.tie(0);
23     cin >> n;
24     for(int i = 0; i < n; i++) {
25         int x, y;
26         cin >> x >> y;
27         x += 1000000000;
28         v.push_back({x, y});
29     }
30     sort(v.begin(), v.end());
31     int l = 0;
32     for(int i = 0; i < n; i++) {
33         int d = ceil(sqrt(dd));
34         while(l < i && v[l].first - v[i].first > d) {
35             s.erase({v[l].second, v[l].first});
36             l++;
37         }
38         auto x = s.lower_bound({v[i].second - d, 0});
39         auto y = s.upper_bound({v[i].second + d, 0});
40         for(auto it = x; it != y; it++) {
41             dd = min(dd, dis({it->second, it->first}, v[i]));
42         }
43         s.insert({v[i].second, v[i].first});
44     }
45     cout << dd;
46 }

```

7. Tree

7.1. HeavyLightDecomposition(modify-and-query-on-path).cpp

```

1  #define int long long
3  using namespace std;
5
7  int tree[800005];
9
10 int n, q;
11 int a[200005];
12 int st[200005];
13 int tp[200005];
14 int p[200005];
15 int cnt = 0;
16 int d[200005];
17 int si[200005];
18 vector<int> v[200005];
19 int b[200005];
20
21 void build(int l = 1, int r = n, int index = 1) {
22     if(l == r) {
23         tree[index] = b[l];
24         return;
25     }
26     int mid = (l + r) >> 1;
27     build(l, mid, index << 1);
28     build(mid + 1, r, index << 1 | 1);
29     tree[index] = max(tree[index << 1], tree[index << 1 | 1]);
30 }
31
32 int query(int L, int R, int l = 1, int r = n, int index = 1) {
33     if(L == l && R == r) {
34         return tree[index];
35     }
36     int mid = (l + r) >> 1;
37     if(R <= mid) {

```

```

38         return query(L, R, l, mid, index << 1);
39     }
40     if(L > mid) {
41         return query(L, R, mid + 1, r, index << 1 | 1);
42     }
43     return max(query(L, mid, l, mid, index << 1),
44               query(mid + 1, R, mid + 1, r, index << 1 | 1));
45 }
46
47 void modify(int x, int val, int l = 1, int r = n,
48             int index = 1) {
49     if(l == r) {
50         tree[index] = val;
51         return;
52     }
53     int mid = (l + r) >> 1;
54     if(x <= mid) {
55         modify(x, val, l, mid, index << 1);
56     } else {
57         modify(x, val, mid + 1, r, index << 1 | 1);
58     }
59     tree[index] = max(tree[index << 1], tree[index << 1 | 1]);
60 }
61
62 void dfs(int x, int pre) {
63     si[x] = 1;
64     for(int i : v[x]) {
65         if(i == pre) continue;
66         p[i] = x;
67         d[i] = d[x] + 1;
68         dfs(i, x);
69         si[x] += si[i];
70     }
71 }
72
73 void dfs2(int x, int pre, int t) {
74     tp[x] = t;
75     st[x] = ++cnt;
76     int ma = 0;
77     for(int i : v[x]) {
78         if(i == pre) continue;
79         if(si[i] > si[ma]) {
80             ma = i;
81         }
82     }
83     if(!ma) return;
84     dfs2(ma, x, t);
85     for(int i : v[x]) {
86         if(i == pre || i == ma) {
87             continue;
88         }
89         dfs2(i, x, i);
90     }
91 }
92
93 int f(int x, int y) {
94     int ret = 0;
95     while(tp[x] ^ tp[y]) {
96         if(d[tp[x]] < d[tp[y]]) {
97             swap(x, y);
98         }
99         ret = max(ret, query(st[tp[x]], st[x]));
100        x = p[tp[x]];
101    }
102    if(d[x] > d[y]) swap(x, y);
103    ret = max(ret, query(st[x], st[y]));
104    return ret;
105 }
106
107 signed main() {
108     ios::sync_with_stdio(0);
109     cin.tie(0);
110     cout.tie(0);
111     cin >> n >> q;
112     for(int i = 1; i <= n; i++) {
113         cin >> a[i];
114     }
115     for(int i = 1; i < n; i++) {
116         int x, y;
117         cin >> x >> y;
118         v[x].push_back(y);
119         v[y].push_back(x);
120     }
121     dfs(1, 0);
122     dfs2(1, 0, 1);
123     for(int i = 1; i <= n; i++) {
124         b[st[i]] = a[i];
125     }
126     build();
127     while(q--) {
128         int mode, x, y;
129         cin >> mode >> x >> y;
130         if(mode == 1) {

```

```

129         modify(st[x], y);
131     } else {
132         cout << f(x, y) << " ";
133     }
}

```

7.2. LCA.cpp

```

1  #define int long long
3  using namespace std;
5  int n, q;
6  int a[200005][21];
7  int d[200005];
8  vector<int> v[200005];
9
10 void init() {
11     for(int j = 1; j < 21; j++) {
12         for(int i = 1; i <= n; i++) {
13             a[i][j] = a[a[i][j-1]][j-1];
14         }
15     }
16 }
17
18 void dfs(int x, int pre) {
19     for(int i : v[x]) {
20         if(i == pre) continue;
21         a[i][0] = x;
22         d[i] = d[x] + 1;
23         dfs(i, x);
24     }
25 }
26
27 int lca(int x, int y) {
28     while(d[x] ^ d[y]) {
29         if(d[x] < d[y]) swap(x, y);
30         int k = __lg(d[x] - d[y]);
31         x = a[x][k];
32     }
33     if(x == y) return x;
34     for(int i = 20; i >= 0; i--) {
35         if(a[x][i] != a[y][i]) {
36             x = a[x][i];
37             y = a[y][i];
38         }
39     }
40     return a[x][0];
41 }
42
43 signed main() {
44     ios::sync_with_stdio(0);
45     cin.tie(0);
46     cout.tie(0);
47     cin >> n >> q;
48     for(int i = 1; i < n; i++) {
49         int x, y;
50         cin >> x >> y;
51         v[x].push_back(y);
52         v[y].push_back(x);
53     }
54     dfs(1, 0);
55     init();
56     while(q--) {
57         int x, y;
58         cin >> x >> y;
59         int k = lca(x, y);
60         cout << (d[x] + d[y] - 2 * d[k]) << "\n";
61     }
62 }

```

8. Misc

8.1. BigNum(luoguP1005).cpp

```

1  //洛谷 P1005
3  using namespace std;
4  #define N 85
5  #define LL long long
6  #define pii pair<int, int>
7  #define F first
8  #define S second
9  struct num {
10     const static LL base = 1000000000LL; // base 1e9

```

```

11     LL p[505], len;
12     num() {
13         memset(p, 0, sizeof(p));
14         len = 0;
15     }
16     num(LL x) {
17         memset(p, 0, sizeof(p));
18         len = 0;
19         for(p[len++] = x; p[len-1] >= base; ++len)
20             p[len] = p[len-1] / base, p[len-1] %= base;
21     }
22     num operator=(LL x) {
23         memset(p, 0, sizeof(p));
24         len = 0;
25         for(p[len++] = x; p[len-1] >= base; ++len)
26             p[len] = p[len-1] / base, p[len-1] %= base;
27         return *this;
28     }
29     num max(const num &b) {
30         if(len != b.len) return len > b.len ? *this : b;
31         for(int i = len; i--;)
32             if(p[i] != b.p[i]) return p[i] > b.p[i] ? *this : b;
33         return *this;
34     }
35     num operator+(const num &b) {
36         num c;
37         LL x = 0;
38         for(LL i = c.len; i < len || i < b.len; ++i) {
39             c.p[i] = p[i] + b.p[i] + x;
40             x = c.p[i] / base;
41             c.p[i] %= base;
42         }
43         if(x) c.p[c.len++] = x;
44         return c;
45     }
46     num operator*(LL b) {
47         num c;
48         c.len = len;
49         LL x = 0;
50         for(LL i = 0; i < len; ++i) {
51             c.p[i] = p[i] * b + x;
52             x = c.p[i] / base;
53             c.p[i] %= base;
54         }
55         for(; x; x /= base) c.p[c.len++] = x % base;
56         return c;
57     }
58     dp[N][N], ans;
59     ostream &operator<<(ostream &s, num a) {
60         if(!a.len) return s << "0";
61         s << a.p[a.len-1];
62         for(int i = a.len-1; i--;) {
63             if(!a.p[i])
64                 s << "000000000";
65             else {
66                 for(int k = 10; k * a.p[i] < (LL)1e9; k *= 10)
67                     s << "0";
68                 s << a.p[i];
69             }
70         }
71         return s;
72     }
73     LL a[N];
74     int main() {
75         ios::sync_with_stdio(0);
76         cin.tie(0);
77         cout.tie(0);
78         int n, m, i, j;
79         for(cin >> n >> m; n--;) {
80             for(i = 0; i < m; ++i) cin >> a[i];
81             for(i = 0; i < m; ++i)
82                 for(j = 0; j < m; ++j) dp[i][j] = 0;
83             for(i = 0; i < m; ++i) dp[i][i] = a[i] << 1;
84             for(j = 1; j < m; ++j)
85                 for(i = 0; i + j < m; ++i)
86                     dp[i][i+j] =
87                         (dp[i][i+j-1] + a[i+j])
88                         .max(dp[i+1][i+j] + a[i]) *
89                         2;
90             ans = ans + dp[0][m-1];
91         }
92         cout << ans;
93     }

```

8.2. Tri-search.cpp

```

1  using namespace std;
3  int n;
4  double a[15], x, y;
5
6  double get(double x) {
7      double ret = 0;

```

```

double k = 1;
for(int i = 0; i <= n; i++) {
    ret += k * a[i];
    k *= x;
}
return -ret;
}

template <class T> T bi_search(T l, T r, T end) {
    if(!check(r - end)) return r - end;
    for(; r - l > end; ) {
        T mid = (l + r) / 2;
        if(check(mid))
            r = mid;
        else
            l = mid;
    }
    return l;
}
/*check gives 000000001111 find the last 0*/

template <class T> T tri_search(T l, T r, T end) {
    T midl, midr;
    for(;;) {
        midl = (l + r) / 2;
        midr = (midl + r) / 2;
        if(midr - midl < end) break;
        if(get(midr) > get(midl))
            r = midr;
        else
            l = midl;
    }
    for(; r - l > end; ) {
        midl = (l + r) / 2;
        if(get(r) > get(l))
            r = midl;
        else
            l = midl;
    }
    return l;
}
/*get gives the value, find the minimum*/

int main() {
    cin >> n >> x >> y;
    for(int i = n; i >= 0; i--) {
        cin >> a[i];
    }
    cout << fixed << setprecision(7)
         << tri_search<double>(x, y, 1e-7);
}

```

9. AnotherVersionDataStructure

9.1. BIT.cpp

```

template <class T> class BIT {
#define lb(x) ((x) & -(x))
#define N (int)2e5 + 5
public:
    T bit[N] = {0};
    void update(T x, T v) {
        for(; x < N; x += lb(x)) bit[x] += v;
    }
    T qry(T x) {
        T ans = 0;
        for(; x != lb(x); ans += bit[x]; x -= lb(x));
        return ans;
    }
#undef lb
#undef N
};
/*1based bit update 預設是加值 */

```

9.2. DSU.cpp

```

template <class T> class Dsu {
#define N 2000005
public:
    T dsu[N], size[N];
    Dsu(T n) {
        for(; n; --n) dsu[n] = n, size[n] = 1;
    }
    T qry(T x) {
        if(dsu[x] == x) return x;
        return dsu[x] = qry(dsu[x]);
    }
    void merge(T a, T b) {
        a = qry(a);
        b = qry(b);
        if(a == b) return;
        if(size[a] < size[b])

```

```

        dsu[a] = b, size[b] += size[a];
    else
        dsu[b] = a, size[a] += size[b];
}
#undef N
};
/*1based 初始化為 dsu[x]=x 路徑壓縮 + 啟發式合併 */

```

9.3. Treap.cpp

```

// treap 模板 洛谷 P3369 【模板】普通平衡树

using namespace std;
#define pnn pair<node *, node *>
#define F first
#define S second
mt19937 mt(hash<string>())("official_beautiful_fruit");
struct node {
    node *l, *r;
    int val, sz;
    int mx, mn, sum;
    int rev_tag, add_tag;
    node(int x)
        : val(x), l(0), r(0), sz(1), rev_tag(0), add_tag(0),
          mx(x), mn(x), sum(x) {}
    node(node *tr)
        : val(tr->val), l(tr->l), r(tr->r), sz(tr->sz),
          rev_tag(tr->rev_tag), add_tag(tr->add_tag),
          mx(tr->mx), mn(tr->mn) {}
    void pull() {
        sz = 1;
        mx = mn = sum = val;
        if(l)
            sz += l->sz, mx = max(mx, l->mx),
            mn = min(mn, l->mn), sum += l->sum;
        if(r)
            sz += r->sz, mx = max(mx, r->mx),
            mn = min(mn, r->mn), sum += r->sum;
    }
    void push() {
        if(rev_tag) swap(l, r);
        if(l) l->add_tag += add_tag, l->rev_tag ^= rev_tag;
        if(r) r->add_tag += add_tag, r->rev_tag ^= rev_tag;
        mx += add_tag;
        mn += add_tag;
        sum += add_tag;
        add_tag = 0;
        rev_tag = 0;
    }
};
void debug(node *tr) {
    if(!tr) return;
    tr->push();
    tr->pull();
    debug(tr->l);
    cout << tr->val << " ";
    debug(tr->r);
}
void debug2(node *tr) {
    if(!tr) return;
    tr->push();
    tr->pull();
    cout << tr->val << " ";
    debug2(tr->l);
    debug2(tr->r);
}
int sz(node *tr) { return tr ? tr->sz : 0; }
node *merge(node *a, node *b) {
    if(!a || !b) return a ? b;
    a->push();
    b->push();
    if(mt() % (sz(a) + sz(b)) < sz(a)) {
        a->r = merge(a->r, b);
        a->pull();
        return a;
    }
    b->l = merge(a, b->l);
    b->pull();
    return b;
}
pnn split(node *tr, int v) { //(-inf,v),(v,inf)
    if(!tr) return {0, 0};
    tr->push();
    if(tr->val <= v) {
        auto [l, r] = split(tr->r, v);
        tr->r = l;
        tr->pull();
        return {tr, r};
    }
    auto [l, r] = split(tr->l, v);
    tr->l = r;
    tr->pull();
    return {l, tr};
}

```

```

}
85 pnn splitsz(node *tr, int k) { //[rk.1,rk.k],[rk.k,rk.n]
    if(!tr || sz(tr) <= k) return {tr, 0};
87     tr->push();
    if(k <= sz(tr->l)) {
89         auto [l, r] = splitsz(tr->l, k);
        tr->l = r;
91         tr->pull();
        return {l, tr};
93     } else if(k <= sz(tr->l) + 1) {
        auto r = tr->r;
95         tr->r = 0;
        tr->pull();
97         return {tr, r};
    } else {
99         auto [l, r] = splitsz(tr->r, k - (sz(tr->l) + 1));
        tr->r = l;
101        tr->pull();
        return {tr, r};
103    }
}
105 node *insert(node *tr, int v) {
    auto [l, r] = split(tr, v);
107     return merge(merge(l, new node(v)), r);
}
109 node *insertkth(node *tr, int k) {
    auto [l, r] = splitsz(tr, k - 1);
111     return merge(merge(l, new node(0)),
        r); // new node 拿來區間操作初始化
113 }
115 node *eraseall(node *tr, int v) {
    auto [l, r] = split(tr, v - 1);
    return merge(l, split(r, v).S);
117 }
119 node *eraseone(node *tr, int v) {
    auto [l, r] = split(tr, v - 1);
    return merge(l, splitsz(r, 1).S);
121 }
123 node *eraskth(node *tr, int k) {
    auto [l, r] = splitsz(tr, k - 1);
    return merge(l, splitsz(r, k).S);
125 }
127 int rnk(node *tr, int v) {
    if(!tr) return 0;
    if(tr->val <= v) return sz(tr->l) + 1 + rnk(tr->r, v);
129     return rnk(tr->l, v);
}
131 int kth(node *tr, int k) {
    auto [l, x] = splitsz(tr, k - 1);
133     auto [m, r] = splitsz(x, 1);
    if(!m) return 0;
135     int ans = m->val;
    tr = merge(merge(l, m), r);
137     return ans;
}
139 int count(node *tr, int L, int R) { // count[L,R]
    auto [l, x] = split(tr, L - 1);
141     auto [m, r] = split(x, R);
    int ans = m->sz; //看要改啥
143     tr = merge(merge(l, m), r);
    return ans;
145 }
147 int countkth(node *tr, int L, int R) { // count[rk.L,rk.R]
    auto [l, x] = splitsz(tr, L - 1);
    auto [m, r] = splitsz(x, R - L);
149     int ans = m->sum; //看要改啥
    tr = merge(merge(l, m), r);
    return ans;
151 }
153 int prev(node *tr, int v) {
    auto [x, r] = splitsz(tr, v - 1);
155     auto [l, m] = splitsz(x, sz(x) - 1);
    int ans = m->val;
157     tr = merge(merge(l, m), r);
    return ans;
159 }
161 int next(node *tr, int v) {
    auto [l, x] = split(tr, v);
    auto [m, r] = splitsz(x, 1);
163     int ans = m->val;
    tr = merge(merge(l, m), r);
165     return ans;
}
167 int qry(node *tr, int L, int R) { // qry[L,R]
    auto [x, r] = splitsz(tr, R);
169     auto [l, m] = splitsz(x, L - 1);
    int ans = m->sum; //看要改啥
171     tr = merge(merge(l, m), r);
    return ans;
173 }
175 void modify(node *tr, int L, int R, int v) { // modify[L,R]
    auto [x, r] = splitsz(tr, R);
    auto [l, m] = splitsz(x, L - 1);

```

```

177     m->val += v;
    m->add_tag += v;
179     m->rev_tag = 1; //看要改啥
    tr = merge(merge(l, m), r);
181 }
183 int main() {
    int t;
    node *tr = 0;
    for(cin >> t; t--;) {
185         int op, x;
        cin >> op >> x;
        switch(op) {
187             case 1:
                tr = insert(tr, x);
                break;
191             case 2:
                tr = eraseone(tr, x);
                break;
193             case 3:
                cout << rnk(tr, x - 1) + 1 << "\n";
                break;
195             case 4:
                cout << kth(tr, x) << "\n";
                break;
197             case 5:
                cout << prev(tr, x) << "\n";
                break;
201             case 6:
                cout << next(tr, x) << "\n";
                break;
203         }
    }
205 }
207 }
209 }

```

9.4. Treap 但可以多個數縮點 (疑似爛的).cpp

```

1 // treap 模板 洛谷 P3369 【模板】普通平衡树
2
3 using namespace std;
4 #define pnn pair<node *, node *>
5 #define F first
6 #define S second
7 #define int long long
8 mt19937 mt(hash<string>{}("official_beautiful_fruit"));
9 struct node {
10     node *l, *r;
11     int val, sz;
12     int mx, mn, sum, num;
13     int rev_tag, add_tag;
14     node(int _val = 0, int _num = 1)
15         : val(_val), l(0), r(0), sz(1), sum(_num), num(_num),
            mx(_val), mn(_val), rev_tag(0), add_tag(0) {}
16     node(node *tr)
17         : val(tr->val), l(tr->l), r(tr->r), sz(tr->sz) {}
18     void pull() {
19         sz = 1;
20         mx = mn = sum = num;
21         if(l)
22             sz += l->sz, mx = max(mx, l->mx),
23             mn = min(mn, l->mn), sum += l->sum;
24         if(r)
25             sz += r->sz, mx = max(mx, r->mx),
26             mn = min(mn, r->mn), sum += r->sum;
27     }
28     void push() {
29         if(rev_tag) swap(l, r);
30         if(l) l->add_tag += add_tag, l->rev_tag ^= rev_tag;
31         if(r) r->add_tag += add_tag, r->rev_tag ^= rev_tag;
32         mx += add_tag;
33         mn += add_tag;
34         sum += add_tag;
35         add_tag = 0;
36         rev_tag = 0;
37     }
38 };
39
40 void debug(node *tr) {
41     if(!tr) return;
42     debug(tr->l);
43     cout << tr->val << " ";
44     debug(tr->r);
45 }
46 void debug2(node *tr) {
47     if(!tr) return;
48     cout << tr->val << " ";
49     debug2(tr->l);
50     debug2(tr->r);
51 }
52 int sz(node *tr) { return tr ? tr->sz : 0; }
53 node *merge(node *a, node *b) {
54     if(!a || !b) return a ? a : b;
55     if(mt() % (sz(a) + sz(b)) < sz(a)) {
56         a->r = merge(a->r, b);
57         a->pull();

```

```

    return a;
}
b->l = merge(a, b->l);
b->pull();
return b;
}
pnn split(node *tr, int v) { //(-inf,v),(v,inf)
    if(!tr) return {0, 0};
    tr->push();
    if(tr->val <= v) {
        auto [l, r] = split(tr->r, v);
        tr->r = l;
        tr->pull();
        return {tr, r};
    }
    auto [l, r] = split(tr->l, v);
    tr->l = r;
    tr->pull();
    return {l, tr};
}
pnn splitsz(node *tr, int k) { //[rk.1,rk.k],[rk.k,rk.n]
    if(!tr || sz(tr) <= k) return {tr, 0};
    tr->push();
    if(k <= sz(tr->l)) {
        auto [l, r] = splitsz(tr->l, k);
        tr->l = r;
        tr->pull();
        return {l, tr};
    } else if(k <= sz(tr->l) + 1) {
        auto r = tr->r;
        tr->r = 0;
        tr->pull();
        return {tr, r};
    } else {
        auto [l, r] = splitsz(tr->r, k - (sz(tr->l) + 1));
        tr->r = l;
        tr->pull();
        return {tr, r};
    }
}
node *insert(node *tr, int val = 0, int num = 1) {
    auto [l, r] = split(tr, val);
    return merge(merge(l, new node(val, num)), r);
}
node *insertkth(node *tr, int k) {
    auto [l, r] = splitsz(tr, k - 1);
    return merge(merge(l, new node()),
        r); // new node 拿來區間操作初始化
}
node *eraseall(node *tr, int v) {
    auto [l, r] = split(tr, v - 1);
    return merge(l, split(r, v).S);
}
node *eraseone(node *tr, int v) {
    auto [l, r] = split(tr, v - 1);
    return merge(l, splitsz(r, 1).S);
}
node *eraskth(node *tr, int k) {
    auto [l, r] = splitsz(tr, k - 1);
    return merge(l, splitsz(r, k).S);
}
}
int rnk(node *tr, int v) {
    if(!tr) return 0;
    if(tr->val <= v) return sz(tr->l) + 1 + rnk(tr->r, v);
    return rnk(tr->l, v);
}
int kth(node *tr, int k) {
    auto [l, x] = splitsz(tr, k - 1);
    auto [m, r] = splitsz(x, 1);
    if(!m) return 0;
    int ans = m->val;
    tr = merge(merge(l, m), r);
    return ans;
}
int count(node *tr, int L, int R) { // count[L,R]
    auto [l, x] = split(tr, L - 1);
    auto [m, r] = split(x, R);
    int ans = m->sum; //看要改啥
    tr = merge(merge(l, m), r);
    return ans;
}
int countkth(node *tr, int L, int R) { // count[rk.L,rk.R]
    auto [l, x] = splitsz(tr, L - 1);
    auto [m, r] = splitsz(x, R - L);
    int ans = m->sum; //看要改啥
    tr = merge(merge(l, m), r);
    return ans;
}
int prev(node *tr, int v) {
    auto [x, r] = split(tr, v - 1);
    auto [l, m] = splitsz(x, sz(x) - 1);
    int ans = m->val;
    tr = merge(merge(l, m), r);
}

```

```

    return ans;
}
int next(node *tr, int v) {
    auto [l, x] = split(tr, v);
    auto [m, r] = splitsz(x, 1);
    int ans = m->val;
    tr = merge(merge(l, m), r);
    return ans;
}
int qry(node *tr, int L, int R) { // qry[L,R]
    auto [l, x] = splitsz(tr, L - 1);
    auto [m, r] = splitsz(x, R);
    int ans = m->sum; //看要改啥
    tr = merge(merge(l, m), r);
    return ans;
}
void modify(node *tr, int L, int R, int v) { // modify[L,R]
    auto [l, x] = splitsz(tr, L - 1);
    auto [m, r] = splitsz(x, R);
    m->val += v;
    m->add_tag += v; //看要改啥
    tr = merge(merge(l, m), r);
}
}
signed main() {
    vector<node *> tr(2);
    int n, m;
    scanf("%lld%lld", &n, &m);
    for(int i = 1, x; i <= n; ++i)
        scanf("%lld", &x), (x) && (tr[1] = insert(tr[1], i, x));
    for(; m--; ) {
        int op = -1, p = -1, x = -1, y = -1;
        scanf("%lld", &op);
        if(!op) {
            scanf("%lld%lld%lld", &p, &x, &y);
            auto [l, tmp] = split(tr[p], x - 1);
            auto [m, r] = split(tmp, y);
            tr[p] = merge(l, r);
            tr.push_back(m);
        } else if(op == 1) {
            scanf("%lld%lld", &p, &x);
            // cout<<kth(tr[x],1)<<"\n";//break;
            auto [l, r] = split(tr[p], kth(tr[x], 1));
            tr[p] = merge(merge(l, tr[x]), r);
        } else
            switch(op) {
                case 2:
                    scanf("%lld%lld%lld", &p, &x, &y);
                    tr[p] = insert(tr[p], y, x);
                    break;
                case 3:
                    scanf("%lld%lld%lld", &p, &x, &y);
                    printf("%lld\n", count(tr[p], x, y));
                    break;
                case 4:
                    scanf("%lld%lld", &p, &x);
                    printf("%lld\n", kth(tr[p], x));
                    break;
            }
    }
}

```

9.5. 區間插線段單點查詢李超 (是爛的).cpp

```

1 // luogu P4097 區間插線段李超
2
3 using namespace std;
4 #define N 50005
5 struct Line {
6     double a, b;
7     int l, r, id; // ax+b{l<=x<=r}
8     Line(double _a = -1e6, double _b = -1, int _l = 1,
9         int _r = N, int _id = 0)
10         : a(_a), b(_b), l(_l), r(_r), id(_id) {}
11     double operator()(int x) { return a * x + b; }
12 } line[N];
13 int seg[N << 2];
14 #define lid(id << 1)
15 #define rid(id << 1 | 1)
16 #define M (L + R >> 1)
17 #define eps 1e-6
18 void ins(int l, int L = 1, int R = N, int id = 1) {
19     // cout<<"ins{"<<line[l].a<<","<<line[l].b<<","<<line[l].l<<","<<line[l].r<<"}\n";
20     // "<<R<<"\n";
21     if(line[l].r < L || R < line[l].l) return;
22     if(L == R) {
23         if(line[l].M - line[seg[id]].M > eps) seg[id] = l;
24         return;
25     }
26     if(line[l].l <= M && M <= line[l].r &&
27         line[l].M - line[seg[id]].M > eps)
28         swap(l, seg[id]);
29     if(line[l].l <= L && R <= line[l].r) {
30         if(line[l].a - line[seg[id]].a > eps)

```



```

31     ins(l, M + 1, R, rid);
32     else
33         ins(l, L, M, lid);
34     }
35     /*if(line[l].a>line[seg[id]].a)*/ ins(l, M + 1, R, rid);
36     /*else */ ins(l, L, M, lid);
37 }
38 int qry(int x, int L = 1, int R = N, int id = 1) {
39     // cout<<"qry"<<x<<"{"<<line[seg[id]].a<<"{"<<line[seg[id]].l<<"{"<<endl;
40     // "<<R<<"{"<<id<<"{"<<endl;
41     if(L == R) return seg[id];
42     int k = (x <= M ? qry(x, L, M, lid)
43         : qry(x, M + 1, R, rid)),
44         not_k = 0, not_seg = 0;
45     if(line[k].r < x || x < line[k].l) not_k = 1;
46     if(line[seg[id]].r < x || x < line[seg[id]].l) not_seg = 1;
47     if(not_k && not_seg) return 0;
48     if(not_k) return seg[id];
49     if(not_seg) return k;
50     return line[k](x) - line[seg[id]](x) > eps ? k : seg[id];
51 }
52 int main() {
53     int n, ans = 0, p = 1;
54     for(cin >> n; n--;) {
55         int op;
56         cin >> op;
57         if(op) {
58             int x0, y0, x1, y1;
59             cin >> x0 >> y0 >> x1 >> y1;
60             x0 = (x0 + ans - 1) % 39989 + 1;
61             y0 = (y0 + ans - 1) % 1000000000 + 1;
62             x1 = (x1 + ans - 1) % 39989 + 1;
63             y1 = (y1 + ans - 1) % 1000000000 + 1;
64             if(x0 > x1) swap(x0, x1), swap(y0, y1);
65             // cout<<"{"<<((double)y1-y0)/(x1-x0)<<"{"<<endl;
66             // "<<y0-x0*((double)y1-y0)/(x1-x0)<<"{"<<endl;
67             if(x0 != x1)
68                 line[p] = Line(((double)y1 - y0) / (x1 - x0),
69                     y0 - x0 * ((double)y1 - y0) / (x1 - x0),
70                     x0, x1, p);
71             else
72                 line[p] = Line(0, max(y0, y1), x0, x1, p);
73             ins(p);
74             ++p;
75         } else {
76             int k;
77             cin >> k;
78             k = (k + ans - 1) % 39989 + 1;
79             cout << (ans = qry(k)) << "\n";
80         }
81     }
82     // cout<<qry(9)<<"{"<<endl;
83 }

```

9.6. 單點修改動態開點線段樹.cpp

```

1 using namespace std;
2 #define N 200005
3 #define M int m = l + r >> 1
4 #define MAX 1000000000
5 int a[N];
6 typedef struct node {
7     struct node *l, *r;
8     int val;
9 };
10 void check(node *tree, int flag) {
11     if(flag && !tree->r)
12         tree->r = (node *)malloc(sizeof(struct node)),
13         tree->r->val = 0;
14     else if(!flag && !tree->l)
15         tree->l = (node *)malloc(sizeof(struct node)),
16         tree->l->val = 0;
17 }
18 void upd(int pos, int val, int l, int r, node *tree) {
19     tree->val += val;
20     if(l == r) return;
21     M;
22     if(pos > m)
23         check(tree, 1), upd(pos, val, m + 1, r, tree->r);
24     else
25         check(tree, 0), upd(pos, val, l, m, tree->l);
26 }
27 int qry(int a, int b, int l, int r, node *tree) {
28     if(!tree) return 0;
29     if(a <= l && r <= b) return tree->val;
30     M;
31     if(a > m) return qry(a, b, m + 1, r, tree->r);
32     if(b <= m) return qry(a, b, l, m, tree->l);
33     return qry(a, b, m + 1, r, tree->r) +
34         qry(a, b, l, m, tree->l);
35 }

```

```

37 int main() {
38     int n, q, i = 1, x;
39     node *root = (node *)malloc(sizeof(struct node));
40     root->val = 0;
41     for(scanf("%d %d", &n, &q); i <= n; ++i)
42         getc(), scanf("%d", &a + i),
43         upd(a[i], 1, 1, MAX, root);
44     // printf("%d %d %d\n", qry(2, 2, 1, n, 1), qry(3, 3, 1, n, 1), qry(5, 5, 1, n, 1), qry(5, 5, 1, n, 1));
45     for(; q--;) {
46         getc();
47         char c = getc();
48         scanf("%d %d", &x, &i);
49         if(c == '!')
50             upd(a[x], -1, 1, MAX, root),
51             a[x] = i, upd(i, 1, 1, MAX, root);
52         else
53             printf("%d\n", qry(x, i, 1, MAX, root));
54     }
55 }

```

9.7. 單點修改無懶標線段樹.cpp

```

1 template <class T> class Seg {
2     #define lid id << 1
3     #define rid id << 1 | 1
4     #define M (L + R >> 1)
5     #define N 200005
6     public:
7         T a[N], seg[N << 2];
8         Seg() {
9             for(int i = 1; i <= n; ++i) cin >> a[i];
10            init();
11        }
12        T update(int pos, int val, int L = 1, int R = n,
13            int id = 1) {
14            if(L == R) return seg[id] = val;
15            if(pos > M)
16                return seg[id] = seg[lid] +
17                    update(pos, val, M + 1, R, rid);
18            return seg[id] = update(pos, val, L, M, lid) + seg[rid];
19        }
20        T qry(int l, int r, int L = 1, int R = n, int id = 1) {
21            if(l <= L && R <= r) return seg[id];
22            if(L == R) return seg[id];
23            int M = L + R >> 1;
24            if(l > M) return qry(l, r, M + 1, R, rid);
25            if(r <= M) return qry(l, r, L, M, lid);
26            return qry(l, M, L, M, lid) +
27                qry(M + 1, r, M + 1, R, rid);
28        }
29        private:
30        T init(int l = 1, int r = n, int id = 1) {
31            if(l == r) return seg[id] = a[l];
32            int m = l + r >> 1;
33            return seg[id] = init(l, m, lid) + init(m + 1, r, rid);
34        }
35        #undef lid
36        #undef rid
37        #undef M
38        #undef N
39    };
40    /*1based 陣列 1based id 單點修改 預設維護區間和 */

```

9.8. 懶標線段樹.cpp

```

1 struct Seg {
2     #define lid (id << 1)
3     #define rid ((id << 1) | 1)
4     #define M (L + R >> 1)
5     #define N 200005
6     LL seg[N << 2], tag[N << 2];
7     void inline addtag(int id, LL v, int L, int R) {
8         seg[id] += v * (R - L + 1);
9         tag[id] += v;
10    }
11    void inline push(int id, int L, int R) {
12        addtag(lid, tag[id], L, M);
13        addtag(rid, tag[id], M + 1, R);
14        tag[id] = 0;
15    }
16    void inline pull(int id) { seg[id] = seg[lid] + seg[rid]; }
17    void init(int L = 1, int R = n, int id = 1) {
18        if(L == R) {
19            seg[id] = 0;
20            tag[id] = 0;
21            return;
22        }
23        init(L, M, lid);
24        init(M + 1, R, rid);
25        pull(id);
26    }

```

```

27 void upd(int l, int r, LL v, int L = 1, int R = n,
28         LL id = 1) {
29     if(l <= L && R <= r) {
30         addtag(id, v, L, R);
31         return;
32     }
33     push(id, L, R);
34     if(r <= M)
35         upd(l, r, v, L, M, lid);
36     else if(M + 1 <= l)
37         upd(l, r, v, M + 1, R, rid);
38     else
39         upd(l, M, v, L, M, lid),
40         upd(M + 1, r, v, M + 1, R, rid);
41     pull(id);
42 }
43 LL qry(int l, int r, int L = 1, int R = n, int id = 1) {
44     if(l <= L && R <= r) return seg[id];
45     push(id, L, R);
46     if(r <= M) return qry(l, r, L, M, lid);
47     if(M + 1 <= l) return qry(l, r, M + 1, R, rid);
48     return qry(l, M, L, M, lid) +
49         qry(M + 1, r, M + 1, R, rid);
50 }
51 } seg;
/*1based 陣列 1based id 區間修改 預設維護區間和 */

```

9.9. 純直線單點查詢李超.cpp

```

1 // luogu P4254 李超
2
3 using namespace std;
4 #define N 50005
5 struct Line {
6     double a, b; // ax+b
7     Line(double _a = -1, double _b = -1e6)
8         : a(_a), b(_b - _a) {}
9     double operator()(int x) { return a * x + b; }
10 } seg[N < 2];
11 #define lid (id << 1)
12 #define rid (id << 1 | 1)
13 #define M (L + R >> 1)
14 void ins(Line l, int L = 1, int R = N, int id = 1) {
15     if(L == R) {
16         if(seg[id].a < 0 || l(M) > seg[id](M)) seg[id] = l;
17         return;
18     }
19     if(l(M) > seg[id](M)) swap(l, seg[id]);
20     if(l.a > seg[id].a)
21         ins(l, M + 1, R, rid);
22     else
23         ins(l, L, M, lid);
24 }
25 double qry(int x, int L = 1, int R = N, int id = 1) {
26     if(L == R) return seg[id](x);
27     if(x <= M) return max(qry(x, L, M, lid), seg[id](x));
28     return max(seg[id](x), qry(x, M + 1, R, rid));
29 }
30 int main() {
31     int n;
32     for(cin >> n; n--;) {
33         string s;
34         cin >> s;
35         if(s[0] == 'Q') {
36             int x;
37             cin >> x;
38             cout << max(0, ((int)(qry(x) * 100)) / 10000)
39                 << "\n";
40         } else {
41             double s, p;
42             cin >> s >> p;
43             ins(Line(p, s));
44         }
45     }
46 }

```

10. AnotherVersionMath

10.1. CRT(luoguVersion).cpp

```

1 long long CRT(long long *W, long long *B,
2              long long k /* 方程组数 */) {
3     long long x, y, a = 0, m, n = 1;
4     for(long long i = 0; i < k; i++) n *= W[i];
5     for(long long i = 0; i < k; i++) {
6         m = n / W[i];
7         ext_gcd(W[i], m, x, y);
8         a = (a + y * m * B[i]) % n;
9     }
10    return a > 0 ? a : a + n;
11 }

```

10.2. PollardRho.cpp

```

1 using namespace std;
2 #define LL long long
3 #define uLL __uint128_t
4 #define sub(a, b) ((a) < (b) ? (b) - (a) : (a) - (b))
5 template <class T, class POW>
6 void fastpow(T x, POW n, POW p, T &ans) {
7     for(; n; n >>= 1) {
8         if(n & 1) {
9             ans *= x;
10            ans %= p;
11        }
12        x *= x;
13        x %= p;
14    }
15 }
16 /* 輸入 x,n,p,ans 會將 ans 修改為 x^n%p
17 對整數/矩陣/不要求精度的浮點 皆有效
18 模板第一個型別是 x,ans 第二個是 n,p(應該放 LL 或 __int128)*/
19 uLL pri[7] = {2, 325, 9375, 28178,
20              450775, 9780504, 1795265022}; /*2^64*/
21 // int p[3]={2,7,61};/*2^32*/
22 bool check(const uLL x, const uLL p) {
23     uLL d = x - 1, ans = 1;
24     fastpow(p, d, x, ans);
25     if(ans != 1) return 1;
26     for(; !(d & 1);) {
27         d >>= 1;
28         ans = 1;
29         fastpow(p, d, x, ans);
30         if(ans == x - 1)
31             return 0;
32         else if(ans != 1)
33             return 1;
34     }
35     return 0;
36 }
37 bool miller_rabin(const uLL x) {
38     if(x == 1) return 0;
39     for(auto e : pri) {
40         if(e >= x) return 1;
41         if(check(x, e)) return 0;
42     }
43     return 1;
44 }
45 template <class T> T gcd(T a, T b) {
46     if(!a) return b;
47     if(!b) return a;
48     if(a & b & 1) return gcd(sub(a, b), min(a, b));
49     if(a & 1) return gcd(a, b >> 1);
50     if(b & 1) return gcd(a >> 1, b);
51     return gcd(a >> 1, b >> 1) << 1;
52 }
53 /*gcd(a,b) 默認 gcd(a,0)=a*/
54 mt19937 rnd(time(0));
55 template <class T> T f(T x, T c, T mod) {
56     return (((uLL)x) * x % mod + c) % mod;
57 }
58 template <class T> T rho(T n) {
59     T mod = n, x = rnd() % mod, c = rnd() % (mod - 1) + 1,
60     p = 1;
61     for(T i = 2, j = 2, d = x;; ++i) {
62         x = f(x, c, mod), p = ((uLL)p * sub(x, d) % mod);
63         if(i % 127 == 0 && gcd(p, n) != 1) return gcd(p, n);
64         if(i == j) {
65             j <<= 1, d = x;
66             if(gcd(p, n) != 1) return gcd(p, n);
67         }
68     }
69 }
70 template <class T> T pollard_rho(T n) {
71     if(miller_rabin(n)) return n;
72     T p = n;
73     while(p == n) p = rho(n);
74     return max(pollard_rho(p), pollard_rho(n / p));
75 }
76 int main() {
77     LL t, n, ans;
78     for(cin >> t; t--;) {
79         cin >> n;
80         ans = pollard_rho(n);
81         if(ans == n)
82             puts("Prime");
83         else
84             printf("%lld\n", ans);
85     }
86 }

```

10.3. 快速幂.cpp

```

1 template <class T, class POW>

```

```

1 void fastpow(T x, POW n, POW p, T &ans) {
2     for(; n >= 1) {
3         if(n & 1) {
4             ans *= x;
5             ans %= p;
6         }
7         x *= x;
8         x %= p;
9     }
10 }
11 /* 輸入 x,n,p,ans 會將 ans 修改為 x^n%p
12 對整數/矩陣/不要求精度的浮點 皆有效
13 模板第一個型別是 x,ans 第二個是 n,p(應該放 LL 或 __int128)*/

```

10.4. 數論.cpp

```

1 template <class T> T extgcd(T a, T b, T &x, T &y) {
2     if(!b) {
3         x = 1;
4         y = 0;
5         return a;
6     }
7     T ans = extgcd(b, a % b, y, x);
8     y -= a / b * x;
9     return ans;
10 }
11 /*extgcd(a,b,x,y)=ax+by, x 跟 y 是會被修改的參數 */
12 template <class T> T modeq(T a, T b, T p) {
13     T x, y, d = extgcd(a, p, x, y);
14     if(b % d) return 0;
15     return ((b / d * x) % p + p) % p;
16 }
17 /*x=modeq(a,b,n), ax=b(mod n), 0<=x<n
18 modeq(a,1,n) 相當於求 a 在 mod n 下的逆元 */
19 template <class T> T gcd(T a, T b) {
20     if(!a) return b;
21     if(!b) return a;
22     if(a & b & 1) return gcd(abs(a - b), min(a, b));
23     if(a & b & 1) return gcd(a, b >> 1);
24     if(b & 1) return gcd(a >> 1, b);
25     return gcd(a >> 1, b >> 1) << 1;
26 }
27 /*gcd(a,b) 默認 gcd(a,0)=a*/
28 ll crt(V<ll> &p, V<ll> &a) {
29     ll n = 1, ans = 0, k = a.size();
30     for(ll &e : p) n *= e;
31     for(int i = 0; i < k; ++i)
32         ans = (ans + a[i] * n / p[i] % n *
33             modeq(n / p[i], 1LL, p[i]) % n) %
34             n;
35     return (ans % n + n) % n;
36 }
37 /*(a+b)^p ≡ a+b ≡ a^p+b^p (mod p) (小費馬)
38 (p-1)! ≡ -1 (mod p) (威爾遜定理)
39 v(n) := n中p的幕次, (n)_p := n/p^{v(n)},
40 s(n) := p進制下n的所有位數和
41 v(n!) = \sum_{i=1}^{\infty} \lfloor \frac{n}{p^i} \rfloor (勒壤得定理)
42 \frac{n!}{p^i} = \frac{n-s(n)}{p-1} (庫默爾定理)
43 v(\frac{n!}{p^i}) = \frac{s(n)+s(m-n)-s(m)}{p-1} (庫默爾定理)
44 v(\frac{(m_1, m_2, \dots, m_k)!}{\sum_{i=1}^k s(m_i)-s(n)}) (庫默爾定理推廣)
45 \lfloor \frac{(n!)_p}{p} \equiv -1^{\lfloor \frac{n}{p} \rfloor} \pmod p
46 \lfloor \frac{((\lfloor \frac{n}{p} \rfloor)!)_p}{p} \equiv -1^{\lfloor \frac{n}{p^2} \rfloor} \pmod p
47 打階乘表 + 迭代這條式子可以 O(p + log_p(n)) (mod p 下階乘)
48 \binom{n}{m} \equiv \frac{((n+m)!)_p}{(n!)_p (m!)_p} \pmod p
49 把 p 從 C(n, m) 裡面隔離掉了 就能用上面的
50 (n!)_p + 模逆元 (mod p 下階乘推廣至二項式)
51 ((p^q)!)_p \equiv \pm 1 \pmod p (威爾遜定理推廣)
52 \lfloor \frac{\binom{n}{m}}{p} \equiv \binom{\lfloor \frac{n}{p} \rfloor}{\lfloor \frac{m}{p} \rfloor} \pmod p
53 \lfloor \frac{\binom{n}{m}}{p} \equiv \binom{\lfloor \frac{n}{p} \rfloor}{\lfloor \frac{m}{p} \rfloor} \pmod p (Lucas 定理) 打階乘表跟模逆元表 + 迭代這條式子可以 O(p + log_p(n))
54 若 p 進制下任何一位 i 滿足 n_i < m_i 則
55 \binom{n}{m} \% p = 0
56 則因 \binom{n}{m} = \prod_{i=0}^{\max(\log_p(a), \log_p(b))} \binom{n_i}{m_i} \% p = 0
57 設 p = 2 則有 \binom{n}{m} 是奇數的充要條件為二進制下每一位
58 n < m (Lucas 定理額外性質) Lucas 定理可由此生成函數做法得到
59 不依賴小費馬 對多項式也成立 根據上述
60 \binom{n}{m} \% k 可將 k 做唯一質數分解
61 個別做完再做 crt 得到結果 (exlucas 定理)
62 \lfloor \frac{C(0)}{p} \equiv C(1) \equiv 1, n > 1 時 C(n) = \sum_{k=0}^{n-1} C(k)C(n-1-k) =
63 \lfloor \frac{C(0)}{p} \equiv C(1) \equiv 1, n > 1 時 C(n) = \sum_{k=0}^{n-1} C(k)C(n-1-k) =

```

```

75 \frac{(2n)!}{n!} 同時 n 對括號的合法放置數即是 C(n) 若有任意 k 種括號可選 則
76 C(n)k^n 模逆元表 p=i*(p/i)+p%i, -p%i=i*(p/i), inv(i)=-(p/i)*inv(p%i)*/
77 LL fracp[N], invp[N];
78 void fracp_init(LL p) {
79     fracp[0] = 1;
80     for(int i = 1; i < p; ++i) fracp[i] = fracp[i - 1] * i % p;
81 }
82 void invp_init(LL p) {
83     invp[0] = invp[1] = 1;
84     for(int i = 2; i < p; ++i)
85         invp[i] = p - (p / i * invp[p % i]) % p;
86 }
87 /* 階乘表跟模逆元表 之後可以考慮改一下長相 */
88 template <class T> T lucas(T n, T m, T p) {
89     if(!m) return 1;
90     if(m > n || m % p > n % p) return 0;
91     return lucas(n / p, m / p, p) * fracp[n % p] % p *
92         invp[fracp[n % p - m % p]] % p * invp[fracp[m % p]] % p;
93 }
94 /*lucas(n,m,p)=C(n,m)%p 要求要帶階乘表跟模逆元表
95 * 0(p+log_p(n))*/
96 /* 米勒拉賓質數 2,325,9375,28178,450775,9780504,1795265022*/
97 /* crt 質數
98 (2^16)+1 65537 3
99 7*17*(2^23)+1 998244353 3
100 1255*(2^20)+1 1315962881 3
101 51*(2^25)+1 1711276033 29
102 */

```

10.5. 篩法.cpp

```

1 //待加入分塊篩
2 template <class T> class Prime {
3     #define N (int)1e8 + 9
4     public:
5         vector<T> list, factor;
6         Prime(T n) {
7             eular(n);
8             // eratosthenes(n);
9             // sqrt_sieve
10            // factorize(n);
11        }
12        void show() {
13            for(T e : list) printf("%lld ", e);
14            putchar('\n');
15        }
16        private:
17            bitset<N> notprime; // 1e8<2^27=128MB
18            void eular(T n) {
19                for(T i = 2; i <= n; ++i) {
20                    if(!notprime[i]) list.emplace_back(i);
21                    const T k = n / i;
22                    for(T j : list) {
23                        if(j > k) break;
24                        notprime[i * j] = 1;
25                        if(!(i % j)) break;
26                    }
27                }
28            }
29            void eratosthenes(T n) {
30                for(T i = 2; i <= n; ++i) {
31                    if(!notprime[i]) list.emplace_back(i);
32                    const T k = n / i;
33                    for(T j : list) {
34                        if(j > k) break;
35                        notprime[i * j] = 1;
36                        if(!(i % j)) break;
37                    }
38                }
39            }
40            void sqrt_sieve(T n) {
41                for(T i = 2; i <= n; ++i) {
42                    bool isprime = 1;
43                    for(T j : list) {
44                        if(j > i / j) break;
45                        if(!(i % j)) {
46                            isprime = 0;
47                            break;
48                        }
49                    }
50                    if(isprime) list.emplace_back(i);
51                }
52            }
53            void factorize(T n) {
54                factor = vector<T>(n);
55                if(list.empty()) eular(n);
56                for(T j : list) factor[j] = j;
57                for(T i = 2; i <= n; ++i) {
58                    const T k = n / i;

```

```

61         for(T j : list) {
62             if(j > k) break;
63             factor[i * j] = j;
64             if(!(i % j)) break;
65         }
66     }
67 #undef N
68 };
69 /*Prime prime(n) 建立打好 1~n 質數表的物件
70 prime.list(一個 vector) 是質數表
71 可修改 define N 決定歐篩/埃篩上限
72 可在建構子選擇篩法 有歐篩/埃篩/根號暴力搜
73 prime.factorize(n) 用歐篩方式得到 1~n 所有數的最小質因數
74 可在 factor(一個 vector) 上一路回溯 logn 得到一個數的質因數分解
75 做 n 個數質因數分解共花 nlogn
76 show() 會以空格隔開 顯示所有 list 內的元素 有尾空格尾換行
77 printf 裡面用%lld 視情況換為%d 或 cout*/

```

11. AnotherVersionString

11.1. KMP (2).cpp

```

1 #define V vector
2 V<int> kmp(string s) {
3     int n = s.size();
4     V<int> f(n);
5     for(int i = 1; i < n; ++i) {
6         int j = f[i - 1];
7         for(; j > 0 && s[j] != s[i];) j = f[j - 1];
8         f[i] = j + (s[j] == s[i]);
9     }
10    return f;
11 }
12 // kmp(s+"#"+t) 得到的陣列中，f[i]=s.size() 的格子代表 t
13 // 中匹配到 s 的結尾位置

```

11.2. KMP.cpp

```

1 class Kmp {
2 #define N 1000005
3 public:
4     int fail[N], p[N];
5     Kmp(char *t, int n) {
6         fail[0] = -1;
7         for(int i = 1; i < n; ++i) {
8             for(fail[i] = fail[i - 1];
9                 t[i] != t[fail[i] + 1] && fail[i] != -1;)
10                fail[i] = fail[fail[i]];
11             if(t[i] == t[fail[i] + 1]) ++fail[i];
12         }
13     }
14     void match(char *s, int n, char *t, int m) {
15         p[0] = (s[0] == t[0]) - 1;
16         for(int i = 1; i < n; ++i) {
17             for(p[i] = p[i - 1];
18                 s[i] != t[p[i] + 1] && p[i] != -1;)
19                p[i] = fail[p[i]];
20             if(s[i] == t[p[i] + 1]) ++p[i];
21         }
22     }
23 #undef N
24 };
25 /*Kmp kmp(t) 會建好 t 的失配函數 fail[]
26 * match 會把每格匹配完的失配函數 p[] 建好 */

```

11.3. Manacher (2).cpp

```

1 #define T(x) ((x)&1 ? s[(x) >> 1] : '.')
2 int ex(string &s, int l, int r, int n) {
3     int i = 0;
4     while(l - i >= 0 && r + i < n && T(l - i) == T(r + i)) ++i;
5     return i;
6 }
7 int manacher(string s, int n) {
8     n = 2 * n + 1;
9     int mx = 0;
10    int center = 0;
11    vector<int> r(n);
12    int ans = 1;
13    r[0] = 1;
14    for(int i = 1; i < n; i++) {
15        int ii = center - (i - center);
16        int len = mx - i + 1;
17        if(i > mx) {
18            r[i] = ex(s, i, i, n);
19            center = i;
20            mx = i + r[i] - 1;
21        } else if(r[ii] == len) {
22            r[i] = len + ex(s, i - len, i + len, n);
23            center = i;

```

```

24            mx = i + r[i] - 1;
25        } else {
26            r[i] = min(r[ii], len);
27        }
28        ans = max(ans, r[i]);
29    }
30    return ans - 1;
31 }

```

11.4. Manacher.cpp

```

1 #define V vector
2 string manacher(string t) {
3     int n = t.size() << 1 | 1;
4     string s(n, '#');
5     for(int i = 0, m = t.size(); i < m; ++i)
6         s[i << 1 | 1] = t[i];
7     V<int> p(n);
8     for(int i = 0, m = 0, r = 0; i < n; ++i) {
9         p[i] = r > i ? min(r - i, p[m - (i - m)]) : 1;
10        for(; i - p[i] >= 0 && i + p[i] < n &&
11            s[i - p[i]] == s[i + p[i]];)
12            ++p[i];
13        if(i + p[i] > r) r = i + p[i], m = i;
14    }
15    int k = 0;
16    string ans = "";
17    for(int i = 0; i < n; ++i)
18        if(p[i] > p[k]) k = i;
19    for(int r = k + p[k], l = k - p[k]; ++l < r;)
20        if(s[l] != '#') ans += s[l];
21    return ans;
22 }
23 // manacher(s) 給出 s
24 // 中的最長回文，若有多個則給字典序最小的，p[i] = 以 i
25 // 為中心的最大回文半徑，所有字之間和頭尾都加上 '#'

```

11.5. Z.cpp

```

1 class Z {
2 public:
3     vector<int> z;
4     Z(string s) {
5         z = vector<int>(s.size());
6         for(int l = 0, i = 1; i < n; ++i) {
7             if(l + z[l] >= i)
8                 z[i] = min(z[l] + l - i, z[i - l]);
9             while(i + z[i] < n && s[z[i]] == s[i + z[i]])
10                ++z[i];
11             if(i + z[i] > l + z[l]) l = i;
12         }
13     }
14 };
15 // Z(s+"#"+t) 得到的陣列中，f[i]=s.size() 的格子代表 t
16 // 中匹配到 s 的開頭位置

```

12. AnotherVersionGraph

12.1. Dijkstra.cpp

```

1 // cses Shortest Routes I
2
3 using namespace std;
4 #define N 100005
5 #define LL long long
6 #define pii pair<int, int>
7 #define pil pair<LL, LL>
8 #define F first
9 #define S second
10 #define pb push_back
11 #define DE if(1)
12 #define INF (LL)1e16
13 vector<pil> adj[N];
14 LL d[N];
15 bitset<N> vis;
16 int main() {
17     int n, m, u, v;
18     LL c;
19     priority_queue<pil, vector<pil>, greater<pil>> q;
20     for(cin >> n >> m; m--;)
21         cin >> u >> v >> c, adj[u].pb({v, c});
22     q.push({0, 1});
23     d[1] = 0;
24     for(u = 2; u <= n; ++u) d[u] = INF;
25     for(; !q.empty(); q.pop()) {
26         if(vis[q.top().S]) continue;
27         vis[q.top().S] = 1;
28         for(auto &e : adj[q.top().S]) {
29             if(!vis[e.F] && q.top().F + e.S < d[e.F]) {
30                 d[e.F] = q.top().F + e.S;
31                 q.push({d[e.F], e.F});

```

```

    }
}
33 }
35 for(u = 1; u <= n; ++u) printf("%lld ", d[u]);
}

```

12.2. SCC.cpp

```

1 using namespace std;
2 #define pb push_back
3 #define pii pair<int, int>
4 #define N 100005
5 vector<int> adj[N];
6 stack<int> st;
7 int dfn[N], low[N], tag, scc[N], scchead[N], sc;
8 bitset<N> in;
9 void dfs(int now, int par = -1) {
10     st.push(now);
11     in[now] = 1;
12     low[now] = dfn[now] = ++tag;
13     for(int e : adj[now]) {
14         if(e == par) continue;
15         if(!dfn[e])
16             dfs(e, now), low[now] = min(low[now], low[e]);
17         else if(in[e])
18             low[now] = min(low[now], dfn[e]);
19     }
20     if(dfn[now] == low[now]) {
21         ++sc;
22         for(; st.top() != now; st.pop())
23             scc[st.top()] = sc, in[st.top()] = 0;
24         st.pop();
25         scc[now] = sc;
26         in[now] = 0;
27         scchead[sc] = now;
28     }
29 }
30 int main() {
31     int n, m, u, v;
32     cin >> n >> m;
33     vector<pii> g(m);
34     for(auto &[u, v] : g)
35         cin >> u >> v, adj[u].pb(v), adj[v].pb(u);
36     for(u = 1; u <= n; ++u)
37         if(!dfn[u]) dfs(u);
38     int ans = 0;
39     for(auto &[u, v] : g)
40         if(scc[u] != scc[v]) ++ans; //eBCC
41     cout << ans << "\n";
42     for(auto &[u, v] : g)
43         if(scc[u] != scc[v]) cout << u << " " << v << "\n";
44 }

```

12.3. cses 有向圖基環樹森林.cpp

```

1 // cses Planets Queries II 基環樹森林模板
2 using namespace std;
3 #define N 200005
4 #define pb push_back
5 // int cyc[i]=1~n 代表 i 屬於哪顆樹
6 // bitset incyc[i]=0/1 代表 i 是否在環上
7 // int len[k]=1~n 代表第 k 棵樹的環長度
8 // int num[i]=1~n 如果 incyc[i] 代表的是在環上的編號
9 // 否則代表的是環上最近的點的編號 int dis[i]=0~n-1
10 // 代表到環上最近點的距離 若 i 在環上則為 0
11 int tag = 1, cyc[N], len[N], num[N], dis[N], nxt[N][19];
12 bitset<N> vis, incyc;
13 vector<int> path;
14 void dfs(int now) {
15     if(vis[now]) {
16         int i = 1;
17         for(int k; k = path.back(), path.pop_back(),
18             k != now && !path.empty(); ++i) {
19             cyc[k] = tag;
20             incyc[k] = 1;
21             num[k] = i;
22         }
23     }
24     cyc[now] = tag;
25     incyc[now] = 1;
26     num[now] = i;
27     len[tag] = i;
28     ++tag;
29     return;
30 }
31 vis[now] = 1;
32 path.pb(now);
33 if(!cyc[nxt[now][0]]) dfs(nxt[now][0]);
34 if(cyc[now]) return;
35 cyc[now] = cyc[nxt[now][0]];
36 num[now] = num[nxt[now][0]];

```

```

    dis[now] = dis[nxt[now][0]] + 1;
}
int jmp(int a, int x) {
    for(int k = 19; k--;)
        for(; 1 <= k <= x; k--) x -= 1 <= k, a = nxt[a][k];
    return a;
}
int main() {
    ios::sync_with_stdio(0);
    cin.tie(0);
    cout.tie(0);
    int n, q, i = 1, u, v;
    for(cin >> n >> q; i <= n; ++i) cin >> nxt[i][0];
    for(int k = 1; k < 19; ++k)
        for(i = 1; i <= n; ++i)
            nxt[i][k] = nxt[nxt[i][k-1]][k-1];
    for(i = 1; i <= n; ++i)
        if(!cyc[i]) path.clear(), dfs(i);
    for(; q--;) {
        cin >> u >> v;
        if(cyc[u] == cyc[v]) {
            if(incyc[v])
                cout << (!incyc[u] ? dis[u] : 0) +
                    (num[u] - num[v] + len[cyc[u]]) %
                    len[cyc[u]]
                    << "\n";
            else if(num[u] == num[v] && dis[u] >= dis[v] &&
                jmp(u, dis[u] - dis[v]) == v)
                cout << dis[u] - dis[v] << "\n";
            else
                cout << "-1\n";
        } else
            cout << "-1\n";
    }
}

```

13. AnotherVersionGeometry

13.1. DynamicHull.cpp

```

1 struct Line {
2     mutable int a, b, r;
3     bool operator<(const Line &o) const { return a < o.a; }
4     bool operator<(const int o) const { return r < o; }
5 };
6
7 struct DynamicHull : multiset<Line, less<>> {
8     inline int Div(int a, int b) {
9         return a / b - ((a ^ b) < 0 && a % b);
10    }
11    inline bool intersect(iterator x, iterator y) {
12        if(y == end()) {
13            x->r = inf;
14            return false;
15        }
16        if(x->a == y->a)
17            x->r = (x->b) > (y->b) ? inf : -inf;
18        else
19            x->r = Div((y->b) - (x->b), (x->a) - (y->a));
20        return (x->r) >= (y->r);
21    }
22    void Insert(int a, int b) {
23        auto y = insert({a, b, 0}), z = next(y), x = y;
24        while(intersect(y, z)) z = erase(z);
25        if(x != begin() && intersect(--x, y))
26            intersect(x, y = erase(y));
27        while((y = x) != begin() && ((-x->r) >= (y->r))
28            intersect(x, erase(y)));
29    }
30    int query(int x) const {
31        auto l = *lower_bound(x);
32        return (l.a) * x + (l.b);
33    }
34 };

```

14. AnotherVersionTree

14.1. LCA.cpp

```

1 #define N 100005
2 #define LG 15
3 int dep[N], par[N][LG], sub[N];
4 vector<int> g[N];
5 void dfs(int now = 1, int pre = 0) {
6     dep[now] = dep[pre] + 1;
7     par[now][0] = pre;
8     sub[now] = 1;
9     for(int e : g[now])
10         if(e != pre) dfs(e, now), sub[now] += sub[e];
11 }

```



```

13 int jmp(int x, int k) {
    for(int i = LG; i--;)
        for(; k >= 1 << i; k -= 1 << i) x = par[x][i];
    return x;
}
17 int lca(int a, int b) {
    if(dep[a] > dep[b]) swap(a, b);
    b = jmp(b, dep[b] - dep[a]);
    if(a == b) return a;
    for(int i = LG; i--;)
        for(; par[a][i] != par[b][i]; b = par[b][i])
            a = par[a][i];
    return par[a][0];
}
25 int main() {
    int n;
    cin >> n;
    for(int i = n, u, v; --i;)
        cin >> u >> v, g[u].pb(v), g[v].pb(u);
    dfs();
    for(int i = 1; i < LG; ++i)
        for(int j = 1; j <= n; ++j)
            par[j][i] = par[par[j][i - 1]][i - 1];
    int k = lca(1, n);
}
37 //點編號 1~n, 建的無向圖但改 dfs
//就能變有向, 改有向記得邊要反著建 dep[n] 代表 n 的深度 (1
39 // base), par[i][j] 代表 i 往上 1<<j 步的祖先是誰, 不存在則是
// 0, sub[i] 代表 i 的子樹大小 jmp(i, j) 代表 i 往上 j
41 // 步的祖先是誰
43 #pragma GCC optimize(
    "Ofast,fast-math,unroll-loops,no-stack-protector")
45 using namespace std;
47 #define ll long long
48 #define pb push_back
49 #define N 200005
50 #define pii pair<int, int>
51 #define V vector
52 #define inf 1000000000
53 #define M 200005
54 #define LG 18
55 #define pii pair<int, int>
56 #define ppp pair<pii, pii>
57 char buf[1 << 22], *p1, *p2;
58 int p[12];
59 #define gc()
    (p1 == p2 &&
61     (p2 = (p1 = buf) + fread(buf, 1, 1 << 22, stdin),
        p1 == p2)
63     ? EOF
        : *p1++)
65 inline int gi() {
    int x = 0;
    for(char c; '0' <= (c = gc()) && c <= '9'; x += c - '0')
        x *= 10;
    return x;
}
67 inline void pi(int x, char c = ' ') {
    if(!x) putchar('0');
    int i = 0;
    for(; x; x /= 10) p[i++] = x % 10;
    for(; i--;) putchar(p[i] + '0');
    putchar(c);
}
71 int main() {
    cin.tie(0)->sync_with_stdio(0);
    int n, m, q;
    cin >> n >> m >> q;
    vector<ppp> g(m);
    bitset<M> ans;
    vector<vector<pii>> adj(n + 1, vector<pii>());
    for(int i = 0; i < m; ++i) {
        auto &p1, p2] = g[i];
        auto &w, idx] = p1;
        auto &u, v] = p2;
        cin >> u >> v >> w;
        idx = i;
    }
    sort(g.begin(), g.end());
    vector<ll> dsu(n + 1, -1);
    auto qry = [&dsu](auto qry, int x) -> int {
        return dsu[x] < 0 ? x : dsu[x] = qry(qry, dsu[x]);
    };
    auto upd = [&dsu, &qry](int u, int v) -> void {
        if(dsu[u] = qry(qry, u)] > dsu[v] = qry(qry, v)])
            swap(u, v);
        dsu[u] += dsu[v];
        dsu[v] = u;
    };
    for(auto &p1, p2] : g) {
        auto &w, idx] = p1;

```

```

105     auto &u, v] = p2;
        if(qry(qry, u) != qry(qry, v))
            upd(u, v), adj[u].pb({v, w}), adj[v].pb({u, w});
    }
    vector<vector<int>> par(n + 1, vector<int>(LG)),
        mx(n + 1, vector<int>(LG));
    vector<int> dep(n + 1);
    auto dfs = [&par, &mx, &dep, &adj](auto dfs, int now,
        int p = 0,
        int w = 0) -> void {
        par[now][0] = p;
        mx[now][0] = w;
        dep[now] = dep[p] + 1;
        for(auto &[e, w] : adj[now])
            if(e != p) dfs(dfs, e, now, w);
    };
    dfs(dfs, 1);
    for(int i = 1; i < LG; ++i)
        for(int j = 1; j <= n; ++j)
            par[j][i] = par[par[j][i - 1]][i - 1],
            mx[j][i] =
                max(mx[j][i - 1], mx[par[j][i - 1]][i - 1]);
    auto lca = [&par, &dep](int u, int v) -> int {
        if(dep[u] > dep[v]) swap(u, v);
        for(int i = LG; i--;)
            if((1 << i) & (dep[v] - dep[u])) v = par[v][i];
        if(u == v) return u;
        for(int i = LG; i--;)
            if(par[u][i] != par[v][i])
                u = par[u][i], v = par[v][i];
        return par[u][0];
    };
    auto path = [&par, &mx, &dep](int k, int x) -> int {
        int ans = 0;
        for(int i = LG; i--;)
            if((1 << i) & (dep[x] - dep[k]))
                ans = max(ans, mx[x][i]), x = par[x][i];
        return ans;
    };
    for(auto &p1, p2] : g) {
        auto &w, idx] = p1;
        auto &u, v] = p2;
        int k = lca(u, v);
        ans[idx] = max(path(k, u), path(k, v)) >= w;
    }
    for(int i = 0; i < m; ++i)
        cout << i << " "
            << (const char[2][5]){ "NO\n", "YES\n"}[ans[i]];
    cout << "\n";
    for(int k; q--;) {
        cin >> k;
        int flag = 1;
        for(int x; k--;) {
            cin >> x;
            if(!ans[x - 1]) flag = 0;
        }
        cout << (const char[2][5]){ "NO\n", "YES\n"}[flag];
    }
}
163

```