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1 Basic

1.1 vimrc

```

colo torte
syn on
se ai ar sm nu rnu is
se mouse=a bs=2 ww+=<, >, [, ] so=6 ts=4 sw=4 tt=100
se makeprg=g++\ -Wall\ -Wshadow\ -O2\ -std=c++0x\ -o\
    %<\ %
au BufNewFile *.cpp 0r ~/default.cpp | :1,$-6 fo
filetype indent on

map <F7> <ESC>:wa<CR>:make!<CR>
imap <F7> <ESC>:wa<CR>:make!<CR>
map <C-F7> <ESC>:tabe %<.in<CR>
map <F8> :cope <CR>
map <S-F8> :ccl <CR>
map <F9> :!./%< <CR>
map <C-F9> :!./%< < %<.in <CR>

```

1.2 IncreaseStackSize

```

//stack resize
asm( "mov %0,%esp\n" ::"g"(mem+100000000) );
//change esp to rsp if 64-bit system

//stack resize (linux)
#include <sys/resource.h>
void increase_stack_size() {
    const rlim_t ks = 64*1024*1024;
    struct rlimit rl;
    int res=getrlimit(RLIMIT_STACK, &rl);
    if(res==0){
        if(rl.rlim_cur<ks){
            rl.rlim_cur=ks;
            res=setrlimit(RLIMIT_STACK, &rl);
        }
    }
}

```

1.3 Default Code

```
#include<bits/stdc++.h>
#include<unistd.h>
using namespace std;
#define FZ(n) memset((n),0,sizeof(n))
#define FMO(n) memset((n),-1,sizeof(n))
#define F first
#define S second
#define PB push_back
#define ALL(x) begin(x),end(x)
#define SZ(x) ((int)(x).size())
#define IOS ios_base::sync_with_stdio(0); cin.tie(0)
#define REP(i,x) for (int i=0; i<(x); i++)
#define REPI(i,a,b) for (int i=(a); i<=(b); i++)
#ifdef ONLINE_JUDGE
#define FILEIO(name) \
    freopen(name".in", "r", stdin); \
    freopen(name".out", "w", stdout);
#else
#define FILEIO(name)
#endif
template<typename A, typename B>
ostream& operator <<(ostream &s, const pair<A,B> &p) {
    return s<<" "<<p.first<<" "<<p.second<<" ";
}
template<typename T>
ostream& operator <<(ostream &s, const vector<T> &c) {
    s<<"[";
    for (auto it : c) s << it << " ";
    s<<"]";
    return s;
}
// Let's Fight!

int main() {
    return 0;
}
```

2 Data Structure

2.1 Bigint

```
struct Bigint{
    static const int LEN = 60;
    static const int BIGMOD = 10000;

    int s;
    int vl, v[LEN];
    // vector<int> v;
    Bigint() : s(1) { vl = 0; }
    Bigint(long long a) {
        s = 1; vl = 0;
        if (a < 0) { s = -1; a = -a; }
        while (a) {
            push_back(a % BIGMOD);
            a /= BIGMOD;
        }
    }
    Bigint(string str) {
        s = 1; vl = 0;
        int stPos = 0, num = 0;
        if (!str.empty() && str[0] == '-') {
            stPos = 1;
            s = -1;
        }
        for (int i=SZ(str)-1, q=1; i>=stPos; i--) {
            num += (str[i] - '0') * q;
            if ((q *= 10) >= BIGMOD) {
                push_back(num);
                num = 0; q = 1;
            }
        }
        if (num) push_back(num);
        n();
    }

    int len() const {
        return vl;
        // return SZ(v);
    }
    bool empty() const { return len() == 0; }
    void push_back(int x) {
        v[vl++] = x;
        // v.PB(x);
    }
    void pop_back() {
        vl--;
        // v.pop_back();
    }
    int back() const {
        return v[vl-1];
        // return v.back();
    }
    void n() {
        while (!empty() && !back()) pop_back();
    }
    void resize(int nl) {
        vl = nl;
        fill(v, v+vl, 0);
        // v.resize(nl);
        // fill(ALL(v), 0);
    }

    void print() const {
        if (empty()) { putchar('0'); return; }
        if (s == -1) putchar('-');
        printf("%d", back());
        for (int i=len()-2; i>=0; i--) printf("%.4d",v[i]);
    }
    friend ostream& operator << (std::ostream& out,
        const Bigint &a) {
        if (a.empty()) { out << "0"; return out; }
        if (a.s == -1) out << "-";
        out << a.back();
        for (int i=a.len()-2; i>=0; i--) {
            char str[10];
            snprintf(str, 5, "%.4d", a.v[i]);
            out << str;
        }
    }
}
```

```

    }
    return out;
}

int cp3(const Bigint &b) const {
    if (s != b.s) return s - b.s;
    if (s == -1) return -(*this).cp3(-b);
    if (len() != b.len()) return len() - b.len(); //int
    for (int i=len()-1; i>=0; i--)
        if (v[i] != b.v[i]) return v[i] - b.v[i];
    return 0;
}

bool operator < (const Bigint &b) const { return cp3(b) < 0; }
bool operator <= (const Bigint &b) const { return cp3(b) <= 0; }
bool operator == (const Bigint &b) const { return cp3(b) == 0; }
bool operator != (const Bigint &b) const { return cp3(b) != 0; }
bool operator > (const Bigint &b) const { return cp3(b) > 0; }
bool operator >= (const Bigint &b) const { return cp3(b) >= 0; }

Bigint operator - () const {
    Bigint r = (*this);
    r.s = -r.s;
    return r;
}

Bigint operator + (const Bigint &b) const {
    if (s == -1) return -(-(*this) + (-b));
    if (b.s == -1) return (*this) - (-b);
    Bigint r;
    int nl = max(len(), b.len());
    r.resize(nl + 1);
    for (int i=0; i<nl; i++) {
        if (i < len()) r.v[i] += v[i];
        if (i < b.len()) r.v[i] += b.v[i];
        if (r.v[i] >= BIGMOD) {
            r.v[i+1] += r.v[i] / BIGMOD;
            r.v[i] %= BIGMOD;
        }
    }
    r.n();
    return r;
}

Bigint operator - (const Bigint &b) const {
    if (s == -1) return -(-(*this) - (-b));
    if (b.s == -1) return (*this) + (-b);
    if ((*this) < b) return -(b - (*this));
    Bigint r;
    r.resize(len());
    for (int i=0; i<len(); i++) {
        r.v[i] += v[i];
        if (i < b.len()) r.v[i] -= b.v[i];
        if (r.v[i] < 0) {
            r.v[i] += BIGMOD;
            r.v[i+1]--;
        }
    }
    r.n();
    return r;
}

Bigint operator * (const Bigint &b) {
    Bigint r;
    r.resize(len() + b.len() + 1);
    r.s = s * b.s;
    for (int i=0; i<len(); i++) {
        for (int j=0; j<b.len(); j++) {
            r.v[i+j] += v[i] * b.v[j];
            if (r.v[i+j] >= BIGMOD) {
                r.v[i+j+1] += r.v[i+j] / BIGMOD;
                r.v[i+j] %= BIGMOD;
            }
        }
    }
    r.n();
    return r;
}

Bigint operator / (const Bigint &b) {

```

```

    Bigint r;
    r.resize(max(1, len() - b.len() + 1));
    int oriS = s;
    Bigint b2 = b; // b2 = abs(b)
    s = b2.s = r.s = 1;
    for (int i=r.len()-1; i>=0; i--) {
        int d=0, u=BIGMOD-1;
        while(d<u) {
            int m = (d+u+1)>>1;
            r.v[i] = m;
            if((r*b2) > (*this)) u = m-1;
            else d = m;
        }
        r.v[i] = d;
    }
    s = oriS;
    r.s = s * b.s;
    r.n();
    return r;
}

Bigint operator % (const Bigint &b) {
    return (*this) - (*this) / b * b;
}
};

```

2.2 unordered_map

```

struct Key {
    int first, second;
    Key () {}
    Key (int _x, int _y) : first(_x), second(_y) {}
    bool operator == (const Key &b) const {
        return tie(F, S) == tie(b.F, b.S);
    }
};

struct KeyHasher {
    size_t operator()(const Key& k) const {
        return k.first + k.second * 1000000;
    }
};

typedef unordered_map<Key, int, KeyHasher> map_t;

int main(int argc, char** argv) {
    map_t mp;
    for (int i=0; i<10; i++)
        mp[Key(i, 0)] = i+1;
    for (int i=0; i<10; i++)
        printf("%d\n", mp[Key(i, 0)]);

    return 0;
}

```

2.3 extc_balance_tree

```

#include <bits/extc++.h>
typedef __gnu_pbds::priority_queue<int> heap_t;
heap_t a, b;

int main() {
    a.clear();
    b.clear();
    a.push(1);
    a.push(3);
    b.push(2);
    b.push(4);
    assert(a.top() == 3);
    assert(b.top() == 4);
    // merge two heap
    a.join(b);
    assert(a.top() == 4);
    assert(b.empty());

    return 0;
}

```

2.4 extc_heap

```
#include <bits/extc++.h>
using namespace __gnu_pbds;
typedef tree<int, null_type, less<int>, rb_tree_tag,
    tree_order_statistics_node_update> set_t;

int main()
{
    // Insert some entries into s.
    set_t s;
    s.insert(12);
    s.insert(505);

    // The order of the keys should be: 12, 505.
    assert(*s.find_by_order(0) == 12);
    assert(*s.find_by_order(3) == 505);

    // The order of the keys should be: 12, 505.
    assert(s.order_of_key(12) == 0);
    assert(s.order_of_key(505) == 1);

    // Erase an entry.
    s.erase(12);

    // The order of the keys should be: 505.
    assert(*s.find_by_order(0) == 505);

    // The order of the keys should be: 505.
    assert(s.order_of_key(505) == 0);
}
```

2.5 Disjoint Set

```
struct DisjointSet {
    // save() is like recursive
    // undo() is like return
    int n, fa[MXN], sz[MXN];
    vector<pair<int*, int*>> h;
    vector<int> sp;
    void init(int tn) {
        n=tn;
        for (int i=0; i<n; i++) {
            fa[i]=i;
            sz[i]=1;
        }
        sp.clear(); h.clear();
    }
    void assign(int *k, int v) {
        h.PB({k, *k});
        *k=v;
    }
    void save() { sp.PB(SZ(h)); }
    void undo() {
        assert(!sp.empty());
        int last=sp.back(); sp.pop_back();
        while (SZ(h)!=last) {
            auto x=h.back(); h.pop_back();
            *x.F=x.S;
        }
    }
    int f(int x) {
        while (fa[x]!=x) x=fa[x];
        return x;
    }
    void uni(int x, int y) {
        x=f(x); y=f(y);
        if (x==y) return;
        if (sz[x]<sz[y]) swap(x, y);
        assign(&sz[x], sz[x]+sz[y]);
        assign(&fa[y], x);
    }
}djs;
```

2.6 Treap

```
const int MEM = 16000004;
struct Treap {
    static Treap nil, mem[MEM], *pmem;
    Treap *l, *r;
    char val;
    int size;
    Treap () : l(&nil), r(&nil), size(0) {}
    Treap (char _val) :
        l(&nil), r(&nil), val(_val), size(1) {}
} Treap::nil, Treap::mem[MEM], *Treap::pmem = Treap::
    mem;

int size(const Treap *t) { return t->size; }
void pull(Treap *t) {
    if (!size(t)) return;
    t->size = size(t->l) + size(t->r) + 1;
}
Treap* merge(Treap *a, Treap *b) {
    if (!size(a)) return b;
    if (!size(b)) return a;
    Treap *t;
    if (rand() % (size(a) + size(b)) < size(a)) {
        t = new (Treap::pmem++) Treap(*a);
        t->r = merge(a->r, b);
    } else {
        t = new (Treap::pmem++) Treap(*b);
        t->l = merge(a, b->l);
    }
    pull(t);
    return t;
}
void split(Treap *t, int k, Treap *&a, Treap *&b) {
    if (!size(t)) a = b = &Treap::nil;
    else if (size(t->l) + 1 <= k) {
        a = new (Treap::pmem++) Treap(*t);
        split(t->r, k - size(t->l) - 1, a->r, b);
        pull(a);
    } else {
        b = new (Treap::pmem++) Treap(*t);
        split(t->l, k, a, b->l);
        pull(b);
    }
}

int nv;
Treap *rt[50005];

void print(const Treap *t) {
    if (!size(t)) return;
    print(t->l);
    cout << t->val;
    print(t->r);
}

int main(int argc, char** argv) {
    IOS;
    rt[nv=0] = &Treap::nil;
    Treap::pmem = Treap::mem;
    int Q, cmd, p, c, v;
    string s;
    cin >> Q;
    while (Q--) {
        cin >> cmd;
        if (cmd == 1) {
            // insert string s after position p
            cin >> p >> s;
            Treap *tl, *tr;
            split(rt[nv], p, tl, tr);
            for (int i=0; i<SZ(s); i++)
                tl = merge(tl, new (Treap::pmem++) Treap(s[i]));
            rt[++nv] = merge(tl, tr);
        } else if (cmd == 2) {
            // remove c characters starting at position
            Treap *tl, *tm, *tr;
            cin >> p >> c;
            split(rt[nv], p-1, tl, tm);
            split(tm, c, tm, tr);
            rt[++nv] = merge(tl, tr);
        } else if (cmd == 3) {
            // print c characters starting at position p, in
            // version v

```

```

    Treap *tl, *tm, *tr;
    cin >> v >> p >> c;
    split(rt[v], p-1, tl, tm);
    split(tm, c, tm, tr);
    print(tm);
    cout << "\n";
}
}
return 0;
}

```

2.7 Heavy Light Decomposition

```

// only one segment tree / no 0/1 base issue
// getPathSeg return the segment in order u->v
// fa[root] = root
typedef pair<int,int> pii;

int N,fa[MXN],belong[MXN],dep[MXN],sz[MXN],que[MXN];
int step,line[MXN],stPt[MXN],edPt[MXN];
vector<int> E[MXN],chain[MXN];

void DFS(int u){
    vector<int> &c = chain[belong[u]];
    for (int i=c.size()-1; i>=0; i--){
        int v = c[i];
        stPt[v] = step;
        line[step++] = v;
    }
    for (int i=0; i<(int)c.size(); i++){
        u = c[i];
        for (auto v : E[u]){
            if (fa[u] == v || (i && v == c[i-1])) continue;
            DFS(v);
        }
        edPt[u] = step-1;
    }
}

void build_chain(int st){
    int fr,bk;
    fr=bk=0; que[bk++] = 1; fa[st]=st; dep[st]=0;
    while (fr < bk){
        int u=que[fr++];
        for (auto v : E[u]){
            if (v == fa[u]) continue;
            que[bk++] = v;
            dep[v] = dep[u]+1;
            fa[v] = u;
        }
    }
    for (int i=bk-1,u,pos; i>=0; i--){
        u = que[i]; sz[u] = 1; pos = -1;
        for (auto v : E[u]){
            if (v == fa[u]) continue;
            sz[u] += sz[v];
            if (pos==-1 || sz[v]>sz[pos]) pos=v;
        }
        if (pos == -1) belong[u] = u;
        else belong[u] = belong[pos];
        chain[belong[u]].PB(u);
    }
    step = 0;
    DFS(st);
}

int getLCA(int u, int v){
    while (belong[u] != belong[v]){
        int a = chain[belong[u]].back();
        int b = chain[belong[v]].back();
        if (dep[a] > dep[b]) u = fa[a];
        else v = fa[b];
    }
    return sz[u] >= sz[v] ? u : v;
}

vector<pii> getPathSeg(int u, int v){
    vector<pii> ret1,ret2;
    while (belong[u] != belong[v]){
        int a = chain[belong[u]].back();
        int b = chain[belong[v]].back();
        if (dep[a] > dep[b]){
            ret1.PB({stPt[a],stPt[u]});

```

```

        u = fa[a];
    } else {
        ret2.PB({stPt[b],stPt[v]});
        v = fa[b];
    }
}
if (dep[u] > dep[v]) swap(u,v);
ret1.PB({stPt[u],stPt[v]});
reverse(ret2.begin(), ret2.end());
ret1.insert(ret1.end(),ret2.begin(),ret2.end());
return ret1;
}

// Usage
void build(){
    build_chain(1); //change root
    init(0,step,0); //init segment tree
}

int get_answer(int u, int v){
    int ret = -2147483647;
    vector<pii> vec = getPathSeg(u,v);
    for (auto it : vec)
        ; // check answer with segment [it.F, it.S]
    return ret;
}

```

2.8 Link-Cut Tree

```

const int MXN = 100005;
const int MEM = 100005;

struct Splay {
    static Splay nil, mem[MEM], *pmem;
    Splay *ch[2], *f;
    int val, rev, size;
    Splay () : val(-1), rev(0), size(0) {
        f = ch[0] = ch[1] = &nil;
    }
    Splay (int _val) : val(_val), rev(0), size(1) {
        f = ch[0] = ch[1] = &nil;
    }
    bool isr() {
        return f->ch[0] != this && f->ch[1] != this;
    }
    int dir() {
        return f->ch[0] == this ? 0 : 1;
    }
    void setCh(Splay *c, int d) {
        ch[d] = c;
        if (c != &nil) c->f = this;
        pull();
    }
    void push() {
        if (rev) {
            swap(ch[0], ch[1]);
            if (ch[0] != &nil) ch[0]->rev ^= 1;
            if (ch[1] != &nil) ch[1]->rev ^= 1;
            rev=0;
        }
    }
    void pull() {
        size = ch[0]->size + ch[1]->size + 1;
        if (ch[0] != &nil) ch[0]->f = this;
        if (ch[1] != &nil) ch[1]->f = this;
    }
} Splay::nil, Splay::mem[MEM], *Splay::pmem = Splay::
mem;
Splay *nil = &Splay::nil;

void rotate(Splay *x) {
    Splay *p = x->f;
    int d = x->dir();
    if (!p->isr()) p->f->setCh(x, p->dir());
    else x->f = p->f;
    p->setCh(x->ch[!d], d);
    x->setCh(p, !d);
    p->pull(); x->pull();
}

vector<Splay*> splayVec;
void splay(Splay *x) {

```

```

splayVec.clear();
for (Splay *q=x;; q=q->f) {
    splayVec.push_back(q);
    if (q->isr()) break;
}
reverse(begin(splayVec), end(splayVec));
for (auto it : splayVec) it->push();
while (!x->isr()) {
    if (x->f->isr()) rotate(x);
    else if (x->dir()==x->f->dir()) rotate(x->f), rotate(x);
    else rotate(x), rotate(x);
}
}

Splay* access(Splay *x) {
    Splay *q = nil;
    for (;x!=nil;x=x->f) {
        splay(x);
        x->setCh(q, 1);
        q = x;
    }
    return q;
}

void evert(Splay *x) {
    access(x);
    splay(x);
    x->rev ^= 1;
    x->push(); x->pull();
}

void link(Splay *x, Splay *y) {
    // evert(x);
    access(x);
    splay(x);
    evert(y);
    x->setCh(y, 1);
}

void cut(Splay *x, Splay *y) {
    // evert(x);
    access(y);
    splay(y);
    y->push();
    y->ch[0] = y->ch[0]->f = nil;
}

int N, Q;
Splay *vt[MXN];

int ask(Splay *x, Splay *y) {
    access(x);
    access(y);
    splay(x);
    int res = x->f->val;
    if (res == -1) res=x->val;
    return res;
}

int main(int argc, char** argv) {
    scanf("%d%d", &N, &Q);
    for (int i=1; i<=N; i++)
        vt[i] = new (Splay::pmem++) Splay(i);
    while (Q--) {
        char cmd[105];
        int u, v;
        scanf("%s", cmd);
        if (cmd[1] == 'i') {
            scanf("%d%d", &u, &v);
            link(vt[v], vt[u]);
        } else if (cmd[0] == 'c') {
            scanf("%d", &v);
            cut(vt[1], vt[v]);
        } else {
            scanf("%d%d", &u, &v);
            int res=ask(vt[u], vt[v]);
            printf("%d\n", res);
        }
    }

    return 0;
}

```

3 Graph

3.1 BCC Edge

```

struct BccEdge {
    static const int MXN = 100005;
    struct Edge { int v, eid; };
    int n, m, step, par[MXN], dfn[MXN], low[MXN];
    vector<Edge> E[MXN];
    DisjointSet djs;
    void init(int _n) {
        n = _n; m = 0;
        for (int i=0; i<n; i++) E[i].clear();
        djs.init(n);
    }
    void add_edge(int u, int v) {
        E[u].PB({v, m});
        E[v].PB({u, m});
        m++;
    }
    void DFS(int u, int f, int f_eid) {
        par[u] = f;
        dfn[u] = low[u] = step++;
        for (auto it:E[u]) {
            if (it.eid == f_eid) continue;
            int v = it.v;
            if (dfn[v] == -1) {
                DFS(v, u, it.eid);
                low[u] = min(low[u], low[v]);
            } else {
                low[u] = min(low[u], dfn[v]);
            }
        }
    }
    void solve() {
        step = 0;
        memset(dfn, -1, sizeof(int)*n);
        for (int i=0; i<n; i++) {
            if (dfn[i] == -1) DFS(i, i, -1);
        }
        djs.init(n);
        for (int i=0; i<n; i++) {
            if (low[i] < dfn[i]) djs.uni(i, par[i]);
        }
    }
}graph;

```

3.2 BCC Vertex

```

struct BccVertex {
    int n, nScc, step, dfn[MXN], low[MXN];
    vector<int> E[MXN], sccv[MXN];
    int top, stk[MXN];
    void init(int _n) {
        n = _n;
        nScc = step = 0;
        for (int i=0; i<n; i++) E[i].clear();
    }
    void add_edge(int u, int v) {
        E[u].PB(v);
        E[v].PB(u);
    }
    void DFS(int u, int f) {
        dfn[u] = low[u] = step++;
        stk[top++] = u;
        for (auto v:E[u]) {
            if (v == f) continue;
            if (dfn[v] == -1) {
                DFS(v, u);
                low[u] = min(low[u], low[v]);
                if (low[v] >= dfn[u]) {
                    int z;
                    sccv[nScc].clear();
                    do {
                        z = stk[--top];
                        sccv[nScc].PB(z);
                    } while (z != v);
                    sccv[nScc].PB(u);
                }
            }
        }
    }
}

```

```

        nScc++;
    }
    } else {
        low[u] = min(low[u], dfn[v]);
    }
}
}
vector<vector<int>> solve() {
    vector<vector<int>> res;
    for (int i=0; i<n; i++) {
        dfn[i] = low[i] = -1;
    }
    for (int i=0; i<n; i++) {
        if (dfn[i] == -1) {
            top = 0;
            DFS(i, i);
        }
    }
    REP(i, nScc) res.PB(sccv[i]);
    return res;
}
}graph;

```

3.3 Strongly Connected Components

```

struct Scc{
    int n, nScc, vst[MXN], bln[MXN];
    vector<int> E[MXN], rE[MXN], vec;
    void init(int _n){
        n = _n;
        for (int i=0; i<MXN; i++){
            E[i].clear();
            rE[i].clear();
        }
    }
    void add_edge(int u, int v){
        E[u].PB(v);
        rE[v].PB(u);
    }
    void DFS(int u){
        vst[u]=1;
        for (auto v : E[u])
            if (!vst[v]) DFS(v);
        vec.PB(u);
    }
    void rDFS(int u){
        vst[u] = 1;
        bln[u] = nScc;
        for (auto v : rE[u])
            if (!vst[v]) rDFS(v);
    }
    void solve(){
        nScc = 0;
        vec.clear();
        FZ(vst);
        for (int i=0; i<n; i++)
            if (!vst[i]) DFS(i);
        reverse(vec.begin(), vec.end());
        FZ(vst);
        for (auto v : vec){
            if (!vst[v]){
                rDFS(v);
                nScc++;
            }
        }
    }
};

```

3.4 DMST_with_sol

```

const int INF = 1029384756;

struct edge_t{
    int u, v, w;
    set< pair<int, int> > add, sub;
    edge_t() : u(-1), v(-1), w(0) {}
    edge_t(int _u, int _v, int _w) {
        u = _u; v = _v; w = _w;
    }
};

```

```

        add.insert({u, v});
    }
    edge_t& operator += (const edge_t& obj) {
        w += obj.w;
        FOR (it, obj.add) {
            if (!sub.count(*it)) add.insert(*it);
            else sub.erase(*it);
        }
        FOR (it, obj.sub) {
            if (!add.count(*it)) sub.insert(*it);
            else add.erase(*it);
        }
        return *this;
    }
    edge_t& operator -= (const edge_t& obj) {
        w -= obj.w;
        FOR (it, obj.sub) {
            if (!sub.count(*it)) add.insert(*it);
            else sub.erase(*it);
        }
        for (auto it : obj.add) {
            if (!add.count(it)) sub.insert(it);
            else add.erase(it);
        }
        return *this;
    }
}eg[MXN*MXN], prv[MXN], EDGE_INF(-1, -1, INF);
int N, M;
int cid, incyc[MXN], contracted[MXN];
vector<int> E[MXN];

edge_t dmst(int rt){
    edge_t cost;
    for (int i=0; i<N; i++){
        contracted[i] = incyc[i] = 0;
        prv[i] = EDGE_INF;
    }
    cid = 0;
    int u, v;
    while (true){
        for (v=0; v<N; v++){
            if (v != rt && !contracted[v] && prv[v].w == INF)
                break;
        }
        if (v >= N) break; // end
        for (int i=0; i<M; i++){
            if (eg[i].v == v && eg[i].w < prv[v].w)
                prv[v] = eg[i];
        }
        if (prv[v].w == INF) // not connected
            return EDGE_INF;
        cost += prv[v];
        for (u=prv[v].u; u!=v && u!=-1; u=prv[u].u);
        if (u == -1) continue;
        incyc[v] = ++cid;
        for (u=prv[v].u; u!=v; u=prv[u].u){
            contracted[u] = 1;
            incyc[u] = cid;
        }
        for (int i=0; i<M; i++){
            if (incyc[eg[i].u] != cid && incyc[eg[i].v] == cid){
                eg[i] -= prv[eg[i].v];
            }
        }
        for (int i=0; i<M; i++){
            if (incyc[eg[i].u] == cid) eg[i].u = v;
            if (incyc[eg[i].v] == cid) eg[i].v = v;
            if (eg[i].u == eg[i].v) eg[i] = eg[--M];
        }
        for (int i=0; i<N; i++){
            if (contracted[i]) continue;
            if (prv[i].u >= 0 && incyc[prv[i].u] == cid)
                prv[i].u = v;
        }
        prv[v] = EDGE_INF;
    }
    return cost;
}

void solve(){
    edge_t cost = dmst(0);
}

```



```

for (auto it : cost.add){ // find a solution
    E[it.F].PB(it.S);
    prv[it.S] = edge_t(it.F,it.S,0);
}
}

```

3.5 Dominator Tree

```

// idom[n] is the unique node that strictly dominates n
// but does
// not strictly dominate any other node that strictly
// dominates n.
// idom[n] = 0 if n is entry or the entry cannot reach
// n.
struct DominatorTree{
    static const int MAXN = 200010;
    int n,s;
    vector<int> g[MAXN],pred[MAXN];
    vector<int> cov[MAXN];
    int dfn[MAXN],nfd[MAXN],ts;
    int par[MAXN];
    int sdom[MAXN],idom[MAXN];
    int mom[MAXN],mn[MAXN];

    inline bool cmp(int u,int v) { return dfn[u] < dfn[v]; }

    int eval(int u) {
        if(mom[u] == u) return u;
        int res = eval(mom[u]);
        if(cmp(sdom[mn[mom[u]]],sdom[mn[u]]))
            mn[u] = mn[mom[u]];
        return mom[u] = res;
    }

    void init(int _n, int _s) {
        n = _n;
        s = _s;
        REP1(i,1,n) {
            g[i].clear();
            pred[i].clear();
            idom[i] = 0;
        }
    }

    void add_edge(int u, int v) {
        g[u].push_back(v);
        pred[v].push_back(u);
    }

    void DFS(int u) {
        ts++;
        dfn[u] = ts;
        nfd[ts] = u;
        for(int v:g[u]) if(dfn[v] == 0) {
            par[v] = u;
            DFS(v);
        }
    }

    void build() {
        ts = 0;
        REP1(i,1,n) {
            dfn[i] = nfd[i] = 0;
            cov[i].clear();
            mom[i] = mn[i] = sdom[i] = i;
        }
        DFS(s);
        for (int i=ts; i>=2; i--) {
            int u = nfd[i];
            if(u == 0) continue;
            for(int v:pred[u]) if(dfn[v]) {
                eval(v);
                if(cmp(sdom[mn[v]],sdom[u])) sdom[u] = sdom[mn[v]];
            }
            cov[sdom[u]].push_back(u);
            mom[u] = par[u];
            for(int w:cov[par[u]]) {
                eval(w);
                if(cmp(sdom[mn[w]],par[u])) idom[w] = mn[w];
                else idom[w] = par[u];
            }
        }
    }
}

```

```

        cov[par[u]].clear();
    }
    REP1(i,2,ts) {
        int u = nfd[i];
        if(u == 0) continue;
        if(idom[u] != sdom[u]) idom[u] = idom[idom[u]];
    }
}
}dom;

```

3.6 Maximum Clique

```

class MaxClique {
public:
    static const int MV = 210;

    int V;
    int el[MV][MV/30+1];
    int dp[MV];
    int ans;
    int s[MV][MV/30+1];
    vector<int> sol;

    void init(int v) {
        V = v; ans = 0;
        FZ(el); FZ(dp);
    }

    /* Zero Base */
    void addEdge(int u, int v) {
        if(u > v) swap(u, v);
        if(u == v) return;
        el[u][v/32] |= (1<<(v%32));
    }

    bool dfs(int v, int k) {
        int c = 0, d = 0;
        for(int i=0; i<(V+31)/32; i++) {
            s[k][i] = el[v][i];
            if(k != 1) s[k][i] &= s[k-1][i];
            c += __builtin_popcount(s[k][i]);
        }
        if(c == 0) {
            if(k > ans) {
                ans = k;
                sol.clear();
                sol.push_back(v);
                return 1;
            }
            return 0;
        }
        for(int i=0; i<(V+31)/32; i++) {
            for(int a = s[k][i]; a; a >> 1) {
                if(k + (c-d) <= ans) return 0;
                int lb = a&(-a), lg = 0;
                a ^= lb;
                while(lb!=1) {
                    lb = (unsigned int)(lb) >> 1;
                    lg++;
                }
                int u = i*32 + lg;
                if(k + dp[u] <= ans) return 0;
                if(dfs(u, k+1)) {
                    sol.push_back(v);
                    return 1;
                }
            }
        }
        return 0;
    }

    int solve() {
        for(int i=V-1; i>=0; i--) {
            dfs(i, 1);
            dp[i] = ans;
        }
        return ans;
    }
};

```



```

    }
}
}
if (dis[t] == INF) break;
long long tf = INF;
for (int v=t, u, l; v!=s; v=u) {
    u=prv[v]; l=prvL[v];
    tf = min(tf, E[u][l].f);
}
for (int v=t, u, l; v!=s; v=u) {
    u=prv[v]; l=prvL[v];
    E[u][l].f -= tf;
    E[v][E[u][l].r].f += tf;
}
cost += tf * dis[t];
fl += tf;
}
return {fl, cost};
}
}f_low;

```

4.3 Kuhn Munkres

```

struct KM{
// Maximum Bipartite Weighted Matching (Perfect Match)
static const int MXN = 650;
static const int INF = 2147483647; // long long
int n, match[MXN], vx[MXN], vy[MXN];
int edge[MXN][MXN], lx[MXN], ly[MXN], slack[MXN];
// ^^^^ long long
void init(int _n){
    n = _n;
    for (int i=0; i<n; i++)
        for (int j=0; j<n; j++)
            edge[i][j] = 0;
}
void add_edge(int x, int y, int w){ // long long
    edge[x][y] = w;
}
bool DFS(int x){
    vx[x] = 1;
    for (int y=0; y<n; y++){
        if (vy[y]) continue;
        if (lx[x]+ly[y] > edge[x][y]){
            slack[y] = min(slack[y], lx[x]+ly[y]-edge[x][y]);
        }
        else {
            vy[y] = 1;
            if (match[y] == -1 || DFS(match[y])){
                match[y] = x;
                return true;
            }
        }
    }
}
return false;
}
int solve(){
    fill(match, match+n, -1);
    fill(lx, lx+n, -INF);
    fill(ly, ly+n, 0);
    for (int i=0; i<n; i++)
        for (int j=0; j<n; j++)
            lx[i] = max(lx[i], edge[i][j]);
    for (int i=0; i<n; i++){
        fill(slack, slack+n, INF);
        while (true){
            fill(vx, vx+n, 0);
            fill(vy, vy+n, 0);
            if (DFS(i)) break;
            int d = INF; // long long
            for (int j=0; j<n; j++)
                if (!vy[j]) d = min(d, slack[j]);
            for (int j=0; j<n; j++){
                if (vx[j]) lx[j] -= d;
                if (vy[j]) ly[j] += d;
                else slack[j] -= d;
            }
        }
    }
}
int res=0;

```

```

    for (int i=0; i<n; i++)
        res += edge[match[i]][i];
    return res;
}
}graph;

```

4.4 SW-Mincut

```

struct SW{ // O(V^3)
static const int MXN = 514;
int n, vst[MXN], del[MXN];
int edge[MXN][MXN], wei[MXN];
void init(int _n){
    n = _n;
    FZ(edge);
    FZ(del);
}
void add_edge(int u, int v, int w){
    edge[u][v] += w;
    edge[v][u] += w;
}
void search(int &s, int &t){
    FZ(vst); FZ(wei);
    s = t = -1;
    while (true){
        int mx=-1, cur=0;
        for (int i=0; i<n; i++)
            if (!del[i] && !vst[i] && mx<wei[i])
                cur = i, mx = wei[i];
        if (mx == -1) break;
        vst[cur] = 1;
        s = t;
        t = cur;
        for (int i=0; i<n; i++)
            if (!vst[i] && !del[i]) wei[i] += edge[cur][i];
    }
}
int solve(){
    int res = 2147483647;
    for (int i=0, x, y; i<n-1; i++){
        search(x, y);
        res = min(res, wei[y]);
        del[y] = 1;
        for (int j=0; j<n; j++)
            edge[x][j] = (edge[j][x] += edge[y][j]);
    }
    return res;
}
}graph;

```

4.5 Maximum Simple Graph Matching

```

struct GenMatch { // 1-base
static const int MAXN = 250;
int V;
bool el[MAXN][MAXN];
int pr[MAXN];
bool inq[MAXN], inp[MAXN], inb[MAXN];
queue<int> qe;
int st, ed;
int nb;
int bk[MAXN], djs[MAXN];
int ans;
void init(int _V) {
    V = _V;
    FZ(el); FZ(pr);
    FZ(inq); FZ(inp); FZ(inb);
    FZ(bk); FZ(djs);
    ans = 0;
}
void add_edge(int u, int v) {
    el[u][v] = el[v][u] = 1;
}
int lca(int u, int v) {
    memset(inp, 0, sizeof(inp));
    while(1) {
        u = djs[u];
        inp[u] = true;
    }
}

```

```

    if(u == st) break;
    u = bk[pr[u]];
}
while(1) {
    v = djs[v];
    if(inp[v]) return v;
    v = bk[pr[v]];
}
return v;
}
void upd(int u) {
    int v;
    while(djs[u] != nb) {
        v = pr[u];
        inb[djs[u]] = inb[djs[v]] = true;
        u = bk[v];
        if(djs[u] != nb) bk[u] = v;
    }
}
void blo(int u,int v) {
    nb = lca(u,v);
    memset(inb,0,sizeof(inb));
    upd(u); upd(v);
    if(djs[u] != nb) bk[u] = v;
    if(djs[v] != nb) bk[v] = u;
    for(int tu = 1; tu <= V; tu++)
        if(inb[djs[tu]]) {
            djs[tu] = nb;
            if(!inq[tu]){
                qe.push(tu);
                inq[tu] = 1;
            }
        }
}
void flow() {
    memset(inq,false,sizeof(inq));
    memset(bk,0,sizeof(bk));
    for(int i = 1; i <= V;i++)
        djs[i] = i;

    while(qe.size()) qe.pop();
    qe.push(st);
    inq[st] = 1;
    ed = 0;
    while(qe.size()) {
        int u = qe.front(); qe.pop();
        for(int v = 1; v <= V; v++)
            if(el[u][v] && (djs[u] != djs[v]) && (pr[u] != v)) {
                if((v == st) || ((pr[v] > 0) && bk[pr[v]] > 0))
                    blo(u,v);
                else if(bk[v] == 0) {
                    bk[v] = u;
                    if(pr[v] > 0) {
                        if(!inq[pr[v]]) qe.push(pr[v]);
                    } else {
                        ed = v;
                        return;
                    }
                }
            }
    }
}
void aug() {
    int u,v,w;
    u = ed;
    while(u > 0) {
        v = bk[u];
        w = pr[v];
        pr[v] = u;
        pr[u] = v;
        u = w;
    }
}
int solve() {
    memset(pr,0,sizeof(pr));
    for(int u = 1; u <= V; u++)
        if(pr[u] == 0) {
            st = u;
            flow();
            if(ed > 0) {

```

```

                aug();
                ans ++;
            }
        }
    }
    return ans;
}
};

int main() {
    gp.init(V);
    for(int i=0; i<E; i++) {
        int u, v;
        cin >> u >> v;
        gp.edge(u, v);
    }
    cout << gp.solve() << endl;
}

```

4.6 Minimum Weight Matching (Clique version)

```

struct Graph {
    // Minimum General Weighted Matching (Perfect Match)
    static const int MXN = 105;

    int n, edge[MXN][MXN];
    int match[MXN],dis[MXN],onstk[MXN];
    vector<int> stk;

    void init(int _n) {
        n = _n;
        FZ(edge);
    }
    void add_edge(int u, int v, int w) {
        edge[u][v] = edge[v][u] = w;
    }
    bool SPFA(int u){
        if (onstk[u]) return true;
        stk.PB(u);
        onstk[u] = 1;
        for (int v=0; v<n; v++){
            if (u != v && match[u] != v && !onstk[v]){
                int m = match[v];
                if (dis[m] > dis[u] - edge[v][m] + edge[u][v]){
                    dis[m] = dis[u] - edge[v][m] + edge[u][v];
                    onstk[v] = 1;
                    stk.PB(v);
                    if (SPFA(m)) return true;
                    stk.pop_back();
                    onstk[v] = 0;
                }
            }
        }
        onstk[u] = 0;
        stk.pop_back();
        return false;
    }

    int solve() {
        // find a match
        for (int i=0; i<n; i+=2){
            match[i] = i+1;
            match[i+1] = i;
        }
        while (true){
            int found = 0;
            FZ(dis); FZ(onstk);
            for (int i=0; i<n; i++){
                stk.clear();
                if (!onstk[i] && SPFA(i)){
                    found = 1;
                    while (SZ(stk)>=2){
                        int u = stk.back(); stk.pop_back();
                        int v = stk.back(); stk.pop_back();
                        match[u] = v;
                        match[v] = u;
                    }
                }
            }
            if (!found) break;
        }
    }
}

```

```

    int ret = 0;
    for (int i=0; i<n; i++)
        ret += edge[i][match[i]];
    ret /= 2;
    return ret;
}
}graph;

```

4.7 2-Commodity Flow

```

const int MAXN = 64;
const int INF = 1029384756;

int N;
int s1, s2, t1, t2, d1, d2, S, T;
int edge[MAXN][MAXN];
int cap[MAXN][MAXN];

int h[MAXN], gap[MAXN];
bool vis[MAXN];

int isap(int v, int f)
{
    if(v == T) return f;

    if(vis[v]) return 0;
    vis[v] = true;

    for(int i=0; i<N+2; i++)
    {
        if(cap[v][i] <= 0) continue;
        if(h[i] != h[v] - 1) continue;
        int res = isap(i, min(cap[v][i], f));
        if(res > 0)
        {
            cap[v][i] -= res;
            cap[i][v] += res;
            return res;
        }
    }

    gap[h[v]]--;
    if(gap[h[v]] <= 0) h[S] = N + 4;
    h[v]++;
    gap[h[v]]++;

    return 0;
}

int get_flow()
{
    for(int i=0; i<MAXN; i++)
    {
        h[i] = gap[i] = 0;
    }
    gap[0] = N + 2;

    int flow = 0;

    while(h[S] <= N + 3)
    {
        for(int i=0; i<N+2; i++)
        {
            vis[i] = false;
        }

        int df = isap(S, INF);
        flow += df;
    }

    return flow;
}

int main()
{
    ios_base::sync_with_stdio(0);

    int TT;
    cin>>TT;
    while(TT--)

```

```

{
    cin>>N;
    cin>>s1>>t1>>d1>>s2>>t2>>d2;

    for(int i=0; i<MAXN; i++)
    {
        for(int j=0; j<MAXN; j++)
        {
            edge[i][j] = 0;
        }
    }

    for(int i=0; i<N; i++)
    {
        string s;
        cin>>s;
        for(int j=0; j<N; j++)
        {
            if(s[j] == 'X') edge[i][j] = 0;
            else if(s[j] == 'O') edge[i][j] = 1;
            else if(s[j] == 'N') edge[i][j] = INF;
        }
    }

    int ans = 0;

    S = N;
    T = N + 1;

    //first
    for(int i=0; i<MAXN; i++)
    {
        for(int j=0; j<MAXN; j++)
        {
            cap[i][j] = edge[i][j];
        }
    }

    cap[S][s1] = cap[t1][T] = d1;
    cap[S][s2] = cap[t2][T] = d2;

    ans = get_flow();

    //second
    for(int i=0; i<MAXN; i++)
    {
        for(int j=0; j<MAXN; j++)
        {
            cap[i][j] = edge[i][j];
        }
    }

    cap[S][s1] = cap[t1][T] = d1;
    cap[S][t2] = cap[s2][T] = d2;

    ans = min(ans, get_flow());

    cout<<(ans == d1 + d2 ? "Yes" : "No")<<endl;
}

return 0;
}

```

4.8 (+1) SW-mincut $O(NM)$

```

// {{{ StoerWagner
const int inf=1000000000;
// should be larger than max.possible mincut
class StoerWagner {
public:
    int n,mc; // node id in [0,n-1]
    vector<int> adj[MAXN];
    int cost[MAXN][MAXN];
    int cs[MAXN];
    bool merged[MAXN],sel[MAXN];
    // --8-- include only if cut is explicitly needed
    DisjointSet djs;
    vector<int> cut;
    //--8<-----
    StoerWagner(int _n):n(_n),mc(inf),djs(_n) {

```

```

    for(int i=0;i<n;i++)
        merged[i]=0;
    for(int i=0;i<n;i++)
        for(int j=0;j<n;j++)
            cost[i][j]=cost[j][i]=0;
}
void append(int v,int u,int c) {
    if(v==u) return;
    if(!cost[v][u]&&c) {
        adj[v].PB(u);
        adj[u].PB(v);
    }
    cost[v][u]+=c;
    cost[u][v]+=c;
}
void merge(int v,int u) {
    merged[u]=1;
    for(int i=0;i<n;i++)
        append(v,i,cost[u][i]);
    // --8<-- include only if cut is explicitly
    //      needed
    djs.merge(v,u);
    //      -----
}
void phase() {
    priority_queue<pii> pq;
    for(int v=0;v<n;v++) {
        if(merged[v]) continue;
        cs[v]=0;
        sel[v]=0;
        pq.push({0,v});
    }
    int v,s,pv;
    while(pq.size()) {
        if(cs[pq.top().S]>pq.top().F) {
            pq.pop();
            continue;
        }
        pv=v;
        v=pq.top().S;
        s=pq.top().F;
        pq.pop();
        sel[v]=1;
        for(int i=0;i<adj[v].size();i++) {
            int u=adj[v][i];
            if(merged[u]||sel[u]) continue;
            cs[u]+=cost[v][u];
            pq.push({cs[u],u});
        }
    }
    if(s<mc) {
        mc=s;
        // --8<-- include only if cut is explicitly
        //      needed -----
        cut.clear();
        for(int i=0;i<n;i++)
            if(djs.getrep(i)==djs.getrep(v)) cut.PB(i);
        // --8<-----
    }
    merge(v,pv);
}
int mincut() {
    if(mc==inf) {
        for(int t=0;t<n-1;t++)
            phase();
    }
    return mc;
}
// --8<-- include only if cut is explicitly needed
// -----
vector<int> getcut() { // return one side of the
    //      cut
    mincut();
    return cut;
}
// --8<-----
};
// }

```

5 Math

5.1 $ax+by=\gcd$

```

typedef pair<int, int> pii;

pii gcd(int a, int b){
    if(b == 0) return make_pair(1, 0);
    else{
        int p = a / b;
        pii q = gcd(b, a % b);
        return make_pair(q.second, q.first - q.second * p);
    }
}

```

5.2 Fast Fourier Transform

```

// const int MAXN = 262144;
// (must be 2^k)

typedef long double ld;
typedef complex<ld> cplx;
const ld PI = acos(-1);
const cplx I(0, 1);

cplx omega[MAXN+1];
void pre_fft()
{
    for(int i=0; i<=MAXN; i++)
        omega[i] = exp(i * 2 * PI / MAXN * I);
}

void fft(int n, cplx a[], bool inv=false)
{
    int basic = MAXN / n;
    int theta = basic;
    for (int m = n; m >= 2; m >= 1) {
        int mh = m >> 1;
        for (int i = 0; i < mh; i++) {
            cplx w = omega[inv ? MAXN-(i*theta%MAXN) : i*
                theta%MAXN];
            for (int j = i; j < n; j += m) {
                int k = j + mh;
                cplx x = a[j] - a[k];
                a[j] += a[k];
                a[k] = w * x;
            }
        }
        theta = (theta * 2) % MAXN;
    }
    int i = 0;
    for (int j = 1; j < n - 1; j++) {
        for (int k = n >> 1; k > (i ^= k); k >= 1);
        if (j < i) swap(a[i], a[j]);
    }
    if (inv)
        for (i = 0; i < n; i++)
            a[i] /= n;
}

```

5.3 Fast Linear Recurrence

```

ll n,m,dp[N+N];
void pre_dp(){
    dp[0]=1;
    ll bdr = min(m+m,n);
    for(ll i=1; i<=bdr; i++)
        for(ll j=i-1; j>=max(0ll,i-m); j--)
            dp[i]= add(dp[i],dp[j]);
}
vector<ll> Mul(const vector<ll>& v1,const vector<ll>&
    v2){
    int sz1 = (int)v1.size();
    int sz2 = (int)v2.size();
    assert(sz1 == m and sz2 == m);
    vector<ll> _v(m+m);
    for(int i=0; i<m+m; i++) _v[i]= 0;
}

```

```

// expand
for(int i=0; i<sz1; i++)
    for(int j=0; j<sz2; j++)
        _v[i+j+1]= add(_v[i+j+1],mul(v1[i],v2[j]));
// shrink
for(int i=0; i<m; i++)
    for(int j=1; j<=m; j++)
        _v[i+j]= add(_v[i+j],_v[i]);
for(int i=0; i<m; i++)
    _v[i]= _v[i+m];
_v.resize(m);
return _v;
}
vector<ll> I,A;
ll solve(){
    pre_dp();
    if(n <= m+m) return dp[n];
    I.resize(m);
    A.resize(m);
    for(int i=0; i<m; i++) I[i]=A[i]=1;
    // dp[n]= /Sum_{i=0}^{m-1} A_i * dp[n-i-1]
    ll dlt = (n-m) / m;
    ll rdlt = dlt * m;
    while(dlt){
        if(dlt & 1ll) I = Mul(I,A);
        A = Mul(A,A);
        dlt >>= 1;
    }
    ll ans = 0;
    for(int i=0; i<m; i++)
        ans = add(ans,mul(I[i],dp[n-i-1-rdlt]));
    return ans;
}

```

5.4 (+1) ntt

```

int P=605028353,root=3,MAXNUM=262144;
// Remember coefficient are mod P
/*
p=a*2^n+1
n    2^n    p    a    root
5    32    97    3    5
6    64    193    3    5
7    128    257    2    3
8    256    257    1    3
9    512    7681    15    17
10   1024    12289    12    11
11   2048    12289    6    11
12   4096    12289    3    11
13   8192    40961    5    3
14   16384    65537    4    3
15   32768    65537    2    3
16   65536    65537    1    3
17   131072    786433    6    10
18   262144    786433    3    10 (605028353,
    2308, 3)
19   524288    5767169    11    3
20   1048576    7340033    7    3
21   2097152    23068673    11    3
22   4194304    104857601    25    3
23   8388608    167772161    20    3
24   16777216    167772161    10    3
25   33554432    167772161    5    3 (1107296257, 33,
    10)
26   67108864    469762049    7    3
27   134217728    2013265921    15    31
*/
int bigmod(long long a,int b){
    if(b==0) return 1;
    return (bigmod((a*a)%P,b/2)*(b%2?a:1ll))%P;
}
int inv(int a,int b){
    if(a==1) return 1;
    return (((long long)(a-inv(b%a,a))*b+1)/a)%b;
}
std::vector<long long> ps(MAXNUM);
std::vector<int> rev(MAXNUM);
struct poly{
    std::vector<unsigned int> co;
    int n;//polynomial degree = n

```

```

poly(int d){n=d;co.resize(n+1,0);}
void trans2(int NN){
    int r=0,st,N;
    unsigned int a,b;
    while((1<<r)<(NN>>1))++r;
    for(N=2;N<=NN;N<=1,--r){
        for(st=0;st<NN;st+=N){
            int i,ss=st+(N>>1);
            for(i=(N>>1)-1;i>=0;--i){
                a=co[st+i]; b=(ps[i<<r]*co[ss+i])%P;
                co[st+i]=a+b; if(co[st+i]>=P)co[st+i]-=P;
                co[ss+i]=a-P-b; if(co[ss+i]>=P)co[ss+i]-=P;
            }
        }
    }
}
void trans1(int NN){
    int r=0,st,N;
    unsigned int a,b;
    for(N=NN;N>1;N>>=1,++r){
        for(st=0;st<NN;st+=N){
            int i,ss=st+(N>>1);
            for(i=(N>>1)-1;i>=0;--i){
                a=co[st+i]; b=co[ss+i];
                co[st+i]=a+b; if(co[st+i]>=P)co[st+i]-=P;
                co[ss+i]=((a-P-b)*ps[i<<r])%P;
            }
        }
    }
}
poly operator*(const poly& _b) const{
    poly a=*this,b=_b;
    int k=n+b.n,i,N=1;
    while(N<=k)N*=2;
    a.co.resize(N,0); b.co.resize(N,0);
    int r=bigmod(root,(P-1)/N),Ni=inv(N,P);
    ps[0]=1;
    for(i=1;i<N;++i)ps[i]=(ps[i-1]*r)%P;
    a.trans1(N);b.trans1(N);
    for(i=0;i<N;++i)a.co[i]=((long long)a.co[i]*b.co[i]
    )%P;
    r=inv(r,P);
    for(i=1;i<N/2;++i)std::swap(ps[i],ps[N-i]);
    a.trans2(N);
    for(i=0;i<N;++i)a.co[i]=((long long)a.co[i]*Ni)%P;
    a.n=n+_b.n; return a;
}
};

```

5.5 Mod

```

/// _fd(a,b) floor(a/b).
/// _rd(a,m) a-floor(a/m)*m.
/// _pv(a,m,r) largest x s.t x<=a && x%m == r.
/// _nx(a,m,r) smallest x s.t x>=a && x%m == r.
/// _ct(a,b,m,r) |A| , A = { x : a<=x<=b && x%m == r }.
int _fd(int a,int b){ return a<0?(-a/b-1):a/b; }
int _rd(int a,int m){ return a-_fd(a,m)*m; }
int _pv(int a,int m,int r){
    {
        r=(r%m+m)%m;
        return _fd(a-r,m)*m+r;
    }
}
int _nt(int a,int m,int r){
    {
        m=abs(m);
        r=(r%m+m)%m;
        return _fd(a-r-1,m)*m+r+m;
    }
}
int _ct(int a,int b,int m,int r){
    {
        m=abs(m);
        a=_nt(a,m,r);
        b=_pv(b,m,r);
        return (a>b)?0:((b-a+m)/m);
    }
}

```

5.6 (+1) Miller Rabin

```
// n < 4,759,123,141      3 : 2, 7, 61
// n < 1,122,004,669,633  4 : 2, 13, 23, 1662803
// n < 3,474,749,660,383  6 : pimes <= 13
// n < 2^64              7 :
// 2, 325, 9375, 28178, 450775, 9780504, 1795265022
// Make sure testing integer is in range [2, n-2] if
// you want to use magic.
long long power(long long x, long long p, long long mod) {
    long long s=1, m=x;
    while(p) {
        if(p&1) s=mult(s, m, mod);
        p>>=1;
        m=mult(m, m, mod);
    }
    return s;
}
bool witness(long long a, long long n, long long u, int t)
{
    long long x=power(a, u, n);
    for(int i=0; i<t; i++) {
        long long nx=mult(x, x, n);
        if(nx==1&&x!=1&&x!=n-1) return 1;
        x=nx;
    }
    return x!=1;
}
bool miller_rabin(long long n, int s=100) {
    // iterate s times of witness on n
    // return 1 if prime, 0 otherwise
    if(n<2) return 0;
    if(!(n&1)) return n==2;
    long long u=n-1;
    int t=0;
    // n-1 = u*2^t
    while(!(u&1)) {
        u>>=1;
        t++;
    }
    while(s--) {
        long long a=randll()%(n-1)+1;
        if(witness(a, n, u, t)) return 0;
    }
    return 1;
}
```

5.7 Pollard Rho

```
// does not work when n is prime
long long modit(long long x, long long mod) {
    if(x>=mod) x-=mod;
    //if(x<0) x+=mod;
    return x;
}
long long mult(long long x, long long y, long long mod) {
    long long s=0, m=x%mod;
    while(y) {
        if(y&1) s=modit(s+m, mod);
        y>>=1;
        m=modit(m+m, mod);
    }
    return s;
}
long long f(long long x, long long mod) {
    return modit(mult(x, x, mod)+1, mod);
}
long long pollard_rho(long long n) {
    if(!(n&1)) return 2;
    while (true) {
        long long y=2, x=rand()%(n-1)+1, res=1;
        for (int sz=2; res==1; sz*=2) {
            for (int i=0; i<sz && res<=1; i++) {
                x = f(x, n);
                res = __gcd(abs(x-y), n);
            }
            y = x;
        }
        if (res!=0 && res!=n) return res;
    }
}
```

```
}
}
```

5.8 Algorithms about Primes

```
/*
 * 12721
 * 13331
 * 14341
 * 75577
 * 123457
 * 222557
 * 556679
 * 999983
 * 1097774749
 * 1076767633
 * 100102021
 * 999997771
 * 1001010013
 * 1000512343
 * 987654361
 * 999991231
 * 999888733
 * 98789101
 * 987777733
 * 999991921
 * 1010101333
 * 1010102101
 * 1000000000039
 * 100000000000037
 * 2305843009213693951
 * 4611686018427387847
 * 9223372036854775783
 * 18446744073709551557
 */
int mu[MX], p_tbl[MX];
vector<int> primes;
void sieve() {
    mu[1] = p_tbl[1] = 1;
    for (int i=2; i<MX; i++) {
        if (!p_tbl[i]) {
            p_tbl[i] = i;
            primes.PB(i);
            mu[i] = -1;
        }
        for (auto p : primes) {
            int x = i*p;
            if (x >= M) break;
            p_tbl[x] = p;
            mu[x] = -mu[i];
            if (i%p==0) {
                mu[x] = 0;
                break;
            }
        }
    }
}
vector<int> factor(int x) {
    vector<int> fac{1};
    while (x > 1) {
        int fn=SZ(fac), p=p_tbl[x], pos=0;
        while (x%p == 0) {
            x /= p;
            for (int i=0; i<fn; i++)
                fac.PB(fac[pos++] * p);
        }
    }
    return fac;
}
```

5.9 (+1) PolynomialGenerator

```
class PolynomialGenerator {
    /* for a nth-order polynomial f(x), *
     * given f(0), f(1), ..., f(n) *
     * express f(x) as sigma_i{c_i*C(x,i)} */
}
```



```

public:
    int n;
    vector<long long> coef;
    // initialize and calculate f(x), vector _fx should
    // be
    // filled with f(0) to f(n)
    PolynomialGenerator(int _n,vector<long long> _fx)
        :n(_n)
        ,coef(_fx) {
        for(int i=0;i<n;i++)
            for(int j=n;j>i;j--)
                coef[j]-=coef[j-1];
    }
    // evaluate f(x), runs in O(n)
    long long eval(int x) {
        long long m=1,ret=0;
        for(int i=0;i<n;i++) {
            ret+=coef[i]*m;
            m=m*(x-i)/(i+1);
        }
        return ret;
    }
};

```

5.10 Pseudoinverse of Square matrix

```

Mat pinv(Mat m)
{
    Mat res = I;

    FZ(used);
    for(int i=0; i<W; i++)
    {
        int piv = -1;
        for(int j=0; j<W; j++)
        {
            if(used[j]) continue;
            if(abs(m.v[j][i]) > EPS)
            {
                piv = j;
                break;
            }
        }
        if(piv == -1)
            continue;
        used[i] = true;
        swap(m.v[piv], m.v[i]);
        swap(res.v[piv], res.v[i]);

        ld rat = m.v[i][i];
        for(int j=0; j<W; j++)
        {
            m.v[i][j] /= rat;
            res.v[i][j] /= rat;
        }

        for(int j=0; j<W; j++)
        {
            if(j == i) continue;
            rat = m.v[j][i];
            for(int k=0; k<W; k++)
            {
                m.v[j][k] -= rat * m.v[i][k];
                res.v[j][k] -= rat * res.v[i][k];
            }
        }

        for(int i=0; i<W; i++)
        {
            if(used[i]) continue;
            for(int j=0; j<W; j++)
                res.v[i][j] = 0;
        }

        return res;
    }
}

```

5.11 Theorem

5.11.1 Lucas' Theorem

For non-negative integer n , m and prime p , $\binom{m}{n} \equiv \prod_{i=0}^k \binom{m_i}{n_i} \pmod{p}$ where m_i is the i -th digit of m in base p .

5.11.2 Sum of Two Squares Thm (Legendre)

For a given positive integer n , let
 $D_1 = (\# \text{ of positive integers } d \text{ dividing } N \text{ that } 1 \equiv d \pmod{4})$
 $D_3 = (\# \text{ of positive integers } d \text{ dividing } N \text{ that } 3 \equiv d \pmod{4})$
 then n can be written as a sum of two squares in exactly
 $R(n) = 4(D_1 - D_3)$ ways.

5.11.3 Difference of D1-D3 Thm

let $n = 2^t \cdot (p_1^{e_1} \cdot \dots \cdot p_r^{e_r}) \cdot (q_1^{f_1} \cdot \dots \cdot q_s^{f_s}) \pmod{4}$
 where p_i, q_i are primes and $1 \equiv p_i \pmod{4}, 3 \equiv q_i \pmod{4}$
 then $D_1 - D_3 = \begin{cases} (e_1 + 1)(e_2 + 1) \dots (e_r + 1), & \text{if } (f_i)s \text{ all even} \\ 0, & \text{if any } f_i \text{ is odd} \end{cases}$

5.11.4 Krush-Kuhn-Tucker Conditions

Stationarity

For maximizing $f(x)$: $\nabla f(x^*) = \sum_{i=1}^m \mu_i \nabla g_i(x^*) + \sum_{j=1}^l \lambda_j \nabla h_j(x^*)$
 For minimizing $f(x)$: $-\nabla f(x^*) = \sum_{i=1}^m \mu_i \nabla g_i(x^*) + \sum_{j=1}^l \lambda_j \nabla h_j(x^*)$

Primal feasibility

$g_i(x^*) \leq 0$, for all $i = 1, \dots, m$
 $h_j(x^*) = 0$, for all $j = 1, \dots, l$

Dual feasibility

$\mu_i \geq 0$, for all $i = 1, \dots, m$

Complementary slackness

$\mu_i g_i(x^*) = 0$, for all $i = 1, \dots, m$

5.11.5 Chinese remainder theorem

$x \equiv r_i \pmod{p_i}$
 $N = \prod p_i$
 $N_i = N/p_i$
 $x \equiv \sum r_i N_i (N_i)^{-1} \pmod{N}$

5.12 Simplex

```

const int maxn = 111;
const int maxm = 111;
const double eps = 1E-10;

double a[maxn][maxm], b[maxn], c[maxn], d[maxn][maxm];
double x[maxm];
int ix[maxn + maxm]; // !!! array all indexed from 0
// max{cx} subject to {Ax<=b, x>=0}
// n: constraints, m: vars !!!
// x[] is the optimal solution vector
//
// usage :
// value = simplex(a, b, c, N, M);
double simplex(double a[maxn][maxm], double b[maxn],
    double c[maxn], int n, int m) {
    ++m;
    int r = n, s = m - 1;
    memset(d, 0, sizeof(d));
    for (int i = 0; i < n + m; ++i) ix[i] = i;
    for (int i = 0; i < n; ++i) {
        for (int j = 0; j < m - 1; ++j) d[i][j] = -a[i][j];
        d[i][m - 1] = 1;
        d[i][m] = b[i];
        if (d[r][m] > d[i][m]) r = i;
    }
    for (int j = 0; j < m - 1; ++j) d[n][j] = c[j];
    d[n + 1][m - 1] = -1;
    for (double dd;; ) {
        if (r < n) {
            int t = ix[s]; ix[s] = ix[r + m]; ix[r + m] = t;
            d[r][s] = 1.0 / d[r][s];

```

```

    for (int j = 0; j <= m; ++j) if (j != s) d[
        r][j] *= -d[r][s];
    for (int i = 0; i <= n + 1; ++i) if (i != r
    ) {
        for (int j = 0; j <= m; ++j) if (j != s
        ) d[i][j] += d[r][j] * d[i][s];
        d[i][s] *= d[r][s];
    }
}
r = -1; s = -1;
for (int j = 0; j < m; ++j) if (s < 0 || ix[s]
> ix[j]) {
    if (d[n + 1][j] > eps || (d[n + 1][j] > -
        eps && d[n][j] > eps)) s = j;
}
if (s < 0) break;
for (int i = 0; i < n; ++i) if (d[i][s] < -eps)
{
    if (r < 0 || (dd = d[r][m] / d[r][s] - d[i
    ][m] / d[i][s]) < -eps || (dd < eps &&
        ix[r + m] > ix[i + m])) r = i;
}
if (r < 0) return -1; // not bounded
}
if (d[n + 1][m] < -eps) return -1; // not
executable
double ans = 0;
for(int i=0; i<m; i++) x[i] = 0;
for (int i = m; i < n + m; ++i) { // the missing
    enumerated x[i] = 0
    if (ix[i] < m - 1)
    {
        ans += d[i - m][m] * c[ix[i]];
        x[ix[i]] = d[i-m][m];
    }
}
return ans;
}
}

```

6 Geometry

6.1 Point operators

```

#define x first
#define y second

#define cpdd const pdd
struct pdd : pair<double, double> {
    using pair<double, double>::pair;

    pdd operator + (cpdd &p) const {
        return {x+p.x, y+p.y};
    }

    pdd operator - () const {
        return {-x, -y};
    }

    pdd operator - (cpdd &p) const {
        return (*this) + (-p);
    }

    pdd operator * (double f) const {
        return {f*x, f*y};
    }

    double operator * (cpdd &p) const {
        return x*p.x + y*p.y;
    }
};

double abs(cpdd &p) { return hypot(p.x, p.y); }
double arg(cpdd &p) { return atan2(p.y, p.x); }
double cross(cpdd &p, cpdd &q) { return p.x*q.y - p.y*q
.x; }
double cross(cpdd &p, cpdd &q, cpdd &o) { return cross(
    p-o, q-o); }
pdd operator * (double f, cpdd &p) { return p*f; } //
!! Not f*p !!

```

6.2 Intersection of two circles

Let $O_1 = (x_1, y_1)$, $O_2 = (x_2, y_2)$ be two centers of circles, r_1, r_2 be the radius. If:
 $d = |O_1 - O_2|$, $u = \frac{1}{2}(O_1 + O_2) + \frac{(r_2^2 - r_1^2)}{2d^2}(O_1 - O_2)$
 $v = \frac{\sqrt{(r_1 + r_2 + d)(r_1 - r_2 + d)(r_1 + r_2 - d)(-r_1 + r_2 + d)}}{2d^2}(y_1 - y_2, -x_1 + x_2)$ then $u + v, u - v$ are the two intersections of the circles, provided that $d < r_1 + r_2$.

```

using ld = double;
vector<pdd> interCircle(pdd o1, double r1, pdd o2,
    double r2) {
    ld d2 = (o1 - o2) * (o1 - o2);
    ld d = sqrt(d2);
    if (d > r1 + r2) return {};
    pdd u = 0.5*(o1+o2) + ((r2*r2-r1*r1)/(2*d2))*(o1-o2);
    double A = sqrt((r1+r2+d) * (r1-r2+d) * (r1+r2-d) *
        (-r1+r2+d));
    pdd v = A / (2*d2) * pdd(o1.S-o2.S, -o1.F+o2.F);
    return {u+v, u-v};
}

```

6.3 Intersection of two lines

```

const double EPS = 1e-9;

pdd interPnt(pdd p1, pdd p2, pdd q1, pdd q2, bool &res)
{
    double f1 = cross(p2, q1, p1);
    double f2 = -cross(p2, q2, p1);
    double f = (f1 + f2);

    if(fabs(f) < EPS) {
        res = false;
        return {};
    }

    res = true;
    return (f2 / f) * q1 + (f1 / f) * q2;
}

```

6.4 Half Plane Intersection

```

const double EPS = 1e-9;

pdd interPnt(Line l1, Line l2, bool &res){
    pdd p1, p2, q1, q2;
    tie(p1, p2) = l1;
    tie(q1, q2) = l2;
    double f1 = cross(p2, q1, p1);
    double f2 = -cross(p2, q2, p1);
    double f = (f1 + f2);

    if(fabs(f) < EPS) {
        res = false;
        return {0, 0};
    }

    res = true;
    return (f2 / f) * q1 + (f1 / f) * q2;
}

bool isin(Line l0, Line l1, Line l2) {
    // Check inter(l1, l2) in l0
    bool res;
    pdd p = interPnt(l1, l2, res);
    return cross(l0.S, p, l0.F) > EPS;
}

/* If no solution, check: 1. ret.size() < 3
 * Or more precisely, 2. interPnt(ret[0], ret[1])
 * in all the lines. (use (l.S - l.F).cross(p - l.F) >
    0
 */
vector<Line> halfPlaneInter(vector<Line> lines) {
    int sz = lines.size();
    vector<double> ata(sz), ord(sz);
    for (int i=0; i<sz; i++) {
        ord[i] = i;
    }
}

```

```

    pdd d = lines[i].S - lines[i].F;
    ata[i] = atan2(d.y, d.x);
}
sort(ALL(ord), [&](int i, int j) {
    if (abs(ata[i] - ata[j]) < EPS) {
        return cross(lines[i].S, lines[j].S, lines[i].F) < 0;
    }
    return ata[i] < ata[j];
});
vector<Line> fin;
for (int i=0; i<sz; i++) {
    if (!i or fabs(ata[ord[i]] - ata[ord[i-1]]) > EPS) {
        fin.PB(lines[ord[i]]);
    }
}

deque<Line> dq;
for (int i=0; i<SZ(fin); i++) {
    while(SZ(dq) >= 2 and
        not isin(fin[i], dq[SZ(dq)-2], dq[SZ(dq)-1])) {
        dq.pop_back();
    }
    while(SZ(dq) >= 2 and
        not isin(fin[i], dq[0], dq[1])) {
        dq.pop_front();
    }
    dq.push_back(fin[i]);
}

while (SZ(dq) >= 3 and
    not isin(dq[0], dq[SZ(dq)-2], dq[SZ(dq)-1])) {
    dq.pop_back();
}

while (SZ(dq) >= 3 and
    not isin(dq[SZ(dq)-1], dq[0], dq[1])) {
    dq.pop_front();
}
vector<Line> res(ALL(dq));
return res;
}

```

6.5 Convex Hull

```

vector<pdd> convex_hull(vector<pdd> pt){
    sort(pt.begin(), pt.end());
    int top=0;
    vector<pdd> stk(2*pt.size());
    for (int i=0; i<(int)pt.size(); i++){
        while (top >= 2 && cross(stk[top-2], stk[top-1], pt[i]) <= 0)
            top--;
        stk[top++] = pt[i];
    }
    for (int i=pt.size()-2, t=top+1; i>=0; i--){
        while (top >= t && cross(stk[top-2], stk[top-1], pt[i]) <= 0)
            top--;
        stk[top++] = pt[i];
    }
    stk.resize(top-1);
    return stk;
}

```

6.6 Minimum Covering Circle

```

struct Mcc{
    // return pair of center and r^2
    static const int MAXN = 1000100;
    int n;
    pdd p[MAXN], cen;
    double r2;

    void init(int _n, pdd _p[]){

```

```

        n = _n;
        memcpy(p, _p, sizeof(pdd)*n);
    }

    double sqr(double a){ return a*a; }
    double abs2(pdd a){ return a*a; }
    pdd center(pdd p0, pdd p1, pdd p2) {
        pdd a = p1-p0;
        pdd b = p2-p0;
        double c1=abs2(a)*0.5;
        double c2=abs2(b)*0.5;
        double d = a % b;
        double x = p0.x + (c1 * b.y - c2 * a.y) / d;
        double y = p0.y + (a.x * c2 - b.x * c1) / d;
        return pdd(x,y);
    }

    pair<pdd, double> solve(){
        random_shuffle(p, p+n);
        r2=0;
        for (int i=0; i<n; i++){
            if (abs2(cen-p[i]) <= r2) continue;
            cen = p[i];
            r2 = 0;
            for (int j=0; j<i; j++){
                if (abs2(cen-p[j]) <= r2) continue;
                cen = 0.5 * (p[i]+p[j]);
                r2 = abs2(cen-p[j]);
                for (int k=0; k<j; k++){
                    if (abs2(cen-p[k]) <= r2) continue;
                    cen = center(p[i], p[j], p[k]);
                    r2 = abs2(cen-p[k]);
                }
            }
            return {cen, r2};
        }
    }
}mcc;

```

6.7 KDTree (Nearest Point)

```

const int MXN = 1000005;

struct KDTree {
    struct Node {
        int x, y, x1, y1, x2, y2;
        int id, f;
        Node *L, *R;
    }tree[MXN];
    int n;
    Node *root;

    long long dis2(int x1, int y1, int x2, int y2) {
        long long dx = x1-x2;
        long long dy = y1-y2;
        return dx*dx+dy*dy;
    }

    static bool cmpx(Node& a, Node& b){ return a.x<b.x; }
    static bool cmpy(Node& a, Node& b){ return a.y<b.y; }
    void init(vector<pair<int, int>> ip) {
        n = ip.size();
        for (int i=0; i<n; i++) {
            tree[i].id = i;
            tree[i].x = ip[i].first;
            tree[i].y = ip[i].second;
        }
        root = build_tree(0, n-1, 0);
    }

    Node* build_tree(int L, int R, int dep) {
        if (L>R) return nullptr;
        int M = (L+R)/2;
        tree[M].f = dep%2;
        nth_element(tree+L, tree+M, tree+R+1, tree[M].f ? cmpy : cmpx);
        tree[M].x1 = tree[M].x2 = tree[M].x;
        tree[M].y1 = tree[M].y2 = tree[M].y;

        tree[M].L = build_tree(L, M-1, dep+1);
        if (tree[M].L) {
            tree[M].x1 = min(tree[M].x1, tree[M].L->x1);
            tree[M].x2 = max(tree[M].x2, tree[M].L->x2);

```

```

    tree[M].y1 = min(tree[M].y1, tree[M].L->y1);
    tree[M].y2 = max(tree[M].y2, tree[M].L->y2);
}

tree[M].R = build_tree(M+1, R, dep+1);
if (tree[M].R) {
    tree[M].x1 = min(tree[M].x1, tree[M].R->x1);
    tree[M].x2 = max(tree[M].x2, tree[M].R->x2);
    tree[M].y1 = min(tree[M].y1, tree[M].R->y1);
    tree[M].y2 = max(tree[M].y2, tree[M].R->y2);
}

return tree+M;
}

int touch(Node* r, int x, int y, long long d2){
    long long dis = sqrt(d2)+1;
    if (x<r->x1-dis || x>r->x2+dis || y<r->y1-dis || y>
        r->y2+dis)
        return 0;
    return 1;
}

void nearest(Node* r, int x, int y, int &mID, long
    long &md2) {
    if (!r || !touch(r, x, y, md2)) return;
    long long d2 = dis2(r->x, r->y, x, y);
    if (d2 < md2 || (d2 == md2 && mID < r->id)) {
        mID = r->id;
        md2 = d2;
    }
    // search order depends on split dim
    if ((r->f == 0 && x < r->x) ||
        (r->f == 1 && y < r->y)) {
        nearest(r->L, x, y, mID, md2);
        nearest(r->R, x, y, mID, md2);
    } else {
        nearest(r->R, x, y, mID, md2);
        nearest(r->L, x, y, mID, md2);
    }
}

int query(int x, int y) {
    int id = 1029384756;
    long long d2 = 102938475612345678LL;
    nearest(root, x, y, id, d2);
    return id;
}
}tree;

```

6.8 (+1) MinkowskiSum

```

/* convex hull Minkowski Sum*/
#define INF 1000000000000000LL
class PT{ public:
    long long x,y;
    int POS(){
        if(y==0) return x>0?0:1;
        return y>0?0:1;
    }
};
PT pt[300000],qt[300000],rt[300000];
long long Lx,Rx;
int dn,un;
inline bool cmp(PT a,PT b){
    int pa=a.POS(),pb=b.POS();
    if(pa==pb) return (a^b)>0;
    return pa<pb;
}
int minkowskiSum(int n,int m){
    int i,j,r,p,q,fi,fj;
    for(i=1,p=0;i<n;i++){
        if(pt[i].y<pt[p].y || (pt[i].y==pt[p].y && pt[i].x<
            pt[p].x)) p=i; }
    for(i=1,q=0;i<m;i++){
        if(qt[i].y<qt[q].y || (qt[i].y==qt[q].y && qt[i].x<
            qt[q].x)) q=i; }
    rt[0]=pt[p]+qt[q];
    r=1; i=p; j=q; fi=fj=0;
    while(1){
        if((fj&&j==q) || ((!fi||i!=p) && cmp(pt[(p+1)%n]-pt
            [p],qt[(q+1)%m]-qt[q]))){

```

```

        rt[r]=rt[r-1]+pt[(p+1)%n]-pt[p];
        p=(p+1)%n;
        fi=1;
    }else{
        rt[r]=rt[r-1]+qt[(q+1)%m]-qt[q];
        q=(q+1)%m;
        fj=1;
    }
    if(r<=1 || ((rt[r]-rt[r-1])^(rt[r-1]-rt[r-2]))!=0)
        r
        ++;
    else rt[r-1]=rt[r];
    if(i==p && j==q) break;
}
return r-1;
}

void initInConvex(int n){
    int i,p,q;
    long long Ly,Ry;
    Lx=INF; Rx=-INF;
    for(i=0;i<n;i++){
        if(pt[i].x<Lx) Lx=pt[i].x;
        if(pt[i].x>Rx) Rx=pt[i].x;
    }
    Ly=Ry=INF;
    for(i=0;i<n;i++){
        if(pt[i].x==Lx && pt[i].y<Ly){ Ly=pt[i].y; p=i; }
        if(pt[i].x==Rx && pt[i].y>Ry){ Ry=pt[i].y; q=i; }
    }
    for(dn=0,i=p;i!=q;i=(i+1)%n){ qt[dn++]=pt[i]; }
    qt[dn]=pt[q]; Ly=Ry=-INF;
    for(i=0;i<n;i++){
        if(pt[i].x==Lx && pt[i].y>Ly){ Ly=pt[i].y; p=i; }
        if(pt[i].x==Rx && pt[i].y<Ry){ Ry=pt[i].y; q=i; }
    }
    for(un=0,i=p;i!=q;i=(i+n-1)%n){ rt[un++]=pt[i]; }
    rt[un]=pt[q];
}

inline int inConvex(PT p){
    int L,R,M;
    if(p.x<Lx || p.x>Rx) return 0;
    L=0;R=dn;
    while(L<R-1){ M=(L+R)/2;
        if(p.x<qt[M].x) R=M; else L=M; }
    if(tri(qt[L],qt[R],p)<0) return 0;
    L=0;R=un;
    while(L<R-1){ M=(L+R)/2;
        if(p.x<rt[M].x) R=M; else L=M; }
    if(tri(rt[L],rt[R],p)>0) return 0;
    return 1;
}

int main(){
    int n,m,i;
    PT p;
    scanf("%d",&n);
    for(i=0;i<n;i++) scanf("%I64d %I64d",&pt[i].x,&pt[i].
        y);
    scanf("%d",&m);
    for(i=0;i<m;i++) scanf("%I64d %I64d",&qt[i].x,&qt[i].
        y);
    n=minkowskiSum(n,m);
    for(i=0;i<n;i++) pt[i]=rt[i];
    scanf("%d",&m);
    for(i=0;i<m;i++) scanf("%I64d %I64d",&qt[i].x,&qt[i].
        y);
    n=minkowskiSum(n,m);
    for(i=0;i<n;i++) pt[i]=rt[i];
    initInConvex(n);
    scanf("%d",&m);
    for(i=0;i<m;i++){
        scanf("%I64d %I64d",&p.x,&p.y);
        p.x*=3; p.y*=3;
        puts(inConvex(p)?"YES":"NO");
    }
}

```

7 Stringology

7.1 Suffix Array

```
const int MAX = 1020304;
int ct[MAX], he[MAX], rk[MAX], sa[MAX], tsa[MAX], tp[
    MAX][2];

void suffix_array(char *ip){

    int len = strlen(ip);
    int alp = 256;

    memset(ct, 0, sizeof(ct));
    for(int i=0;i<len;i++) ct[ip[i]+1]++;
    for(int i=1;i<alp;i++) ct[i]+=ct[i-1];
    for(int i=0;i<len;i++) rk[i]=ct[ip[i]];

    for(int i=1;i<len;i*=2){
        for(int j=0;j<len;j++){
            if(j+i>len) tp[j][1]=0;
            else tp[j][1]=rk[j+i]+1;

            tp[j][0]=rk[j];
        }
        memset(ct, 0, sizeof(ct));
        for(int j=0;j<len;j++) ct[tp[j][1]+1]++;
        for(int j=1;j<len+1;j++) ct[j]+=ct[j-1];
        for(int j=0;j<len;j++) tsa[ct[tp[j][1]]+j]=j;

        memset(ct, 0, sizeof(ct));
        for(int j=0;j<len;j++) ct[tp[j][0]+1]++;
        for(int j=1;j<len+1;j++) ct[j]+=ct[j-1];
        for(int j=0;j<len;j++) sa[ct[tp[tsa[j]][0]]+j]=tsa[j];

        rk[sa[0]]=0;
        for(int j=1;j<len;j++){
            if( tp[sa[j]][0] == tp[sa[j-1]][0] &&
                tp[sa[j]][1] == tp[sa[j-1]][1] )
                rk[sa[j]] = rk[sa[j-1]];
            else
                rk[sa[j]] = j;
        }

        for(int i=0,h=0;i<len;i++){
            if(rk[i]==0) h=0;
            else{
                int j=sa[rk[i]-1];
                h=max(0,h-1);
                for(;ip[i+h]==ip[j+h];h++);
            }
            he[rk[i]]=h;
        }
    }
}
```

7.2 Suffix Array (SAIS TWT514)

```
struct SA{
#define REP(i,n) for ( int i=0; i<int(n); i++ )
#define REP1(i,a,b) for ( int i=(a); i<int(b); i++ )
    static const int MXN = 300010;
    bool _t[MXN*2];
    int _s[MXN*2], _sa[MXN*2], _c[MXN*2], x[MXN], _p[
        MXN], _q[MXN*2], hei[MXN], r[MXN];
    int operator [] (int i){ return _sa[i]; }
    void build(int *s, int n, int m){
        memcpy(_s, s, sizeof(int) * n);
        sais(_s, _sa, _p, _q, _t, _c, n, m);
        mkhei(n);
    }
    void mkhei(int n){
        REP(i,n) r[_sa[i]] = i;
        hei[0] = 0;
        REP(i,n) if(r[i]) {
            int ans = i>0 ? max(hei[r[i-1]] - 1, 0) :
                0;
        }
    }
}
```

```
while(_s[i+ans] == _s[_sa[r[i]-1]+ans]) ans
    ++;
    hei[r[i]] = ans;
}

void sais(int *s, int *sa, int *p, int *q, bool *t,
    int *c, int n, int z){
    bool uniq = t[n-1] = true, neq;
    int nn = 0, nmzx = -1, *nsa = sa + n, *ns = s +
        n, lst = -1;
#define MS0(x,n) memset((x),0,n*sizeof(*(x)))
#define MAGIC(XD) MS0(sa, n); \
    memcpy(x, c, sizeof(int) * z); \
    XD; \
    memcpy(x + 1, c, sizeof(int) * (z - 1)); \
    REP(i,n) if(sa[i] && !t[sa[i]-1]) sa[x[s[sa[i]
        ]-1]]++ = sa[i]-1; \
    memcpy(x, c, sizeof(int) * z); \
    for(int i = n - 1; i >= 0; i--) if(sa[i] && t[
        sa[i]-1]) sa[--x[s[sa[i]-1]]] = sa[i]-1;
    MS0(c, z);
    REP(i,n) uniq &= ++c[s[i]] < 2;
    REP(i,z-1) c[i+1] += c[i];
    if (uniq) { REP(i,n) sa[--c[s[i]]] = i; return;
    }
    for(int i = n - 2; i >= 0; i--) t[i] = (s[i]==s
        [i+1] ? t[i+1] : s[i]<s[i+1]);
    MAGIC(REP1(i,1,n-1) if(t[i] && !t[i-1]) sa[--x[
        s[i]]]=p[q[i]=nn++]=i);
    REP(i, n) if (sa[i] && t[sa[i]] && !t[sa[i]-1])
        {
            neq=lst<0||memcmp(s+sa[i],s+lst,(p[q[sa[i]
                ]+1]-sa[i])*sizeof(int));
            ns[q[lst=sa[i]]]=nmzx+=neq;
        }
    sais(ns, nsa, p + nn, q + n, t + n, c + z, nn,
        nmzx + 1);
    MAGIC(for(int i = nn - 1; i >= 0; i--) sa[--x[s
        [p[nsa[i]]]]] = p[nsa[i]]);
}
}sa;

void suffix_array(int* ip, int len) {
    // should padding a zero in the back
    // s is int array, n is array length
    // s[0..n-1] != 0, and s[n] = 0
    // resulting SA will be length n+1
    ip[len++] = 0;
    sa.build(ip, len, 128);
    // original 1-base
    for (int i=0; i<l; i++) {
        hei[i] = sa.hei[i + 1];
        sa[i] = sa._sa[i + 1];
    }
}
```

7.3 Aho-Corasick Algorithm

```
struct ACautomata{
    struct Node{
        int cnt,dp;
        Node *go[26], *fail;
        Node (){
            cnt = 0;
            dp = -1;
            memset(go,0,sizeof(go));
            fail = 0;
        }
    };

    Node *root, pool[1048576];
    int nMem;

    Node* new_Node(){
        pool[nMem] = Node();
        return &pool[nMem++];
    }
    void init(){
        nMem = 0;
        root = new_Node();
    }
}
```

```

}
void add(const string &str){
    insert(root,str,0);
}
void insert(Node *cur, const string &str, int pos){
    if (pos >= (int)str.size()){
        cur->cnt++;
        return;
    }
    int c = str[pos]-'a';
    if (cur->go[c] == 0){
        cur->go[c] = new_Node();
    }
    insert(cur->go[c],str,pos+1);
}
void make_fail(){
    queue<Node*> que;
    que.push(root);
    while (!que.empty()){
        Node* fr=que.front();
        que.pop();
        for (int i=0; i<26; i++){
            if (fr->go[i]){
                Node *ptr = fr->fail;
                while (ptr && !ptr->go[i]) ptr = ptr->fail;
                if (!ptr) fr->go[i]->fail = root;
                else fr->go[i]->fail = ptr->go[i];
                que.push(fr->go[i]);
            }
        }
    }
}
};

```

7.4 KMP

```

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

void build_fail_function(string B, int *fail) {
    int len = B.length(), pos;
    pos = fail[0] = -1;
    for (int i = 1; i < len; i++) {
        while (pos != -1 and B[pos + 1] != B[i])
            pos = fail[pos];
        if (B[pos + 1] == B[i]) pos++;
        fail[i] = pos;
    }
}

void match(string A, string B, int *fail) {
    int lenA = A.length(), lenB = B.length();
    int pos = -1;
    for (int i = 0; i < lenA; i++) {
        while (pos != -1 and B[pos + 1] != A[i])
            pos = fail[pos];

        if (B[pos + 1] == A[i]) pos++;

        if (pos == lenB - 1) {
            // Match ! A[i - lenB + 1, i] = B
            pos = fail[pos];
        }
    }
}

```

7.5 Z value

```

void Zval(const char *s, int len, int *z) {
    z[0] = 0;
    for (int b=0, i=1; i<len; i++) {
        z[i] = max(min(z[i-b], z[b] + b - i), 0);
        while (s[i + z[i]] == s[z[i]]) z[i]++;
        if (i+z[i] > b+z[b]) b=i;
    }
}

```

7.6 Z value (palindrome ver.)

```

void Zpal(const char *s, int len, int *z) {
    // Only odd palindrome len is considered
    // z[i] means that the longest odd palindrom
    // centered at
    // i is [i-z[i] .. i+z[i]]
    z[0] = 0;
    for (int b=0, i=1; i<len; i++) {
        if (z[b] + b >= i) z[i] = min(z[2*b-i], b+z[b]-i);
        else z[i] = 0;
        while (i+z[i]+1 < len and i-z[i]-1 >= 0 and
            s[i+z[i]+1] == s[i-z[i]-1]) z[i]++;
        if (z[i] + i > z[b] + b) b = i;
    }
}

```

7.7 palindromic tree

```

struct palindromic_tree{
    struct node{
        int next[26],fail,len;
        int cnt,num,st,ed;
        node(int l=0):fail(0),len(l),cnt(0),num(0){
            for(int i=0;i<26;++i)next[i]=0;
        }
    };
    vector<node> state;
    vector<char> s;
    int last,n;
    palindromic_tree():state(2),last(1),n(0){
        state[0].fail=1;
        state[1].len=-1;
        s.push_back(-1);
    }
    inline void clear(){
        state.clear();
        s.clear();
        last=1;
        n=0;
        state.push_back(0);
        state.push_back(-1);
        state[0].fail=1;
        s.push_back(-1);
    }
    inline int get_fail(int x){
        while(s[n-state[x].len-1]!=s[n])x=state[x].fail;
        return x;
    }
    inline void add(int c){
        s.push_back(c-'a');
        ++n;
        int cur=get_fail(last);
        if(!state[cur].next[c]){
            int now=state.size();
            state.push_back(state[cur].len+2);
            state[now].fail=state[get_fail(state[cur].fail)].next[c];
            state[cur].next[c]=now;
            state[now].num=state[state[now].fail].num+1;
        }
        last=state[cur].next[c];
        ++state[last].cnt;
    }
    inline void count(){
        vector<node>::reverse_iterator i=state.rbegin();
        for(;i!=state.rend();++i){
            state[i->fail].cnt+=i->cnt;
        }
    }
    inline int size(){
        return state.size()-2;
    }
};

```

7.8 Lexicographically Smallest Rotation

```
string mcp(string s){
    int n = s.length();
    s += s;
    int i=0, j=1;
    while (i<n && j<n){
        int k = 0;
        while (k < n && s[i+k] == s[j+k]) k++;
        if (s[i+k] <= s[j+k]) j += k+1;
        else i += k+1;
        if (i == j) j++;
    }
    int ans = i < n ? i : j;
    return s.substr(ans, n);
}
```

7.9 Suffix Automaton

```
// par : fail link
// val : a topological order ( useful for DP )
// go[x] : automata edge ( x is integer in [0,26) )

struct SAM{
    struct State{
        int par, go[26], val;
        State () : par(0), val(0){ FZ(go); }
        State (int _val) : par(0), val(_val){ FZ(go); }
    };
    vector<State> vec;
    int root, tail;

    void init(int arr[], int len){
        vec.resize(2);
        vec[0] = vec[1] = State(0);
        root = tail = 1;
        for (int i=0; i<len; i++)
            extend(arr[i]);
    }

    void extend(int w){
        int p = tail, np = vec.size();
        vec.PB(State(vec[p].val+1));
        for ( ; p && vec[p].go[w]==0; p=vec[p].par)
            vec[p].go[w] = np;
        if (p == 0){
            vec[np].par = root;
        } else {
            if (vec[vec[p].go[w]].val == vec[p].val+1){
                vec[np].par = vec[p].go[w];
            } else {
                int q = vec[p].go[w], r = vec.size();
                vec.PB(vec[q]);
                vec[r].val = vec[p].val+1;
                vec[q].par = vec[np].par = r;
                for ( ; p && vec[p].go[w] == q; p=vec[p].par)
                    vec[p].go[w] = r;
            }
        }
        tail = np;
    }
};
```

8 Problems

8.1 Find the maximun tangent (x,y is increasing)

```
typedef long long LL;
const int MAXN = 100010;
struct Coord{
    LL x, y;
    Coord operator - (Coord ag) const{
        Coord res;
        res.x = x - ag.x;
        res.y = y - ag.y;
        return res;
    }
}sum[MAXN], pnt[MAXN], ans, calc;
```

```
inline bool cross(Coord a, Coord b, Coord c){
    return (c.y - a.y) * (c.x - b.x) > (c.x - a.x) * (c.y - b.y);
}

int main(){
    int n, l, np, st, ed, now;
    scanf("%d %d\n", &n, &l);
    sum[0].x = sum[0].y = np = st = ed = 0;
    for (int i = 1, v; i <= n; i++){
        scanf("%d", &v);
        sum[i].y = sum[i-1].y + v;
        sum[i].x = i;
    }
    ans.x = now = 1;
    ans.y = -1;
    for (int i = 0; i <= n - l; i++){
        while (np > 1 && cross(pnt[np-2], pnt[np-1], sum[i]))
            np--;
        if (np < now && np != 0) now = np;
        pnt[np++] = sum[i];
        while (now < np && !cross(pnt[now-1], pnt[now], sum[i+l]))
            now++;
        calc = sum[i+l] - pnt[now-1];
        if (ans.y * calc.x < ans.x * calc.y){
            ans = calc;
            st = pnt[now-1].x;
            ed = i + l;
        }
    }
    double res = (sum[ed].y - sum[st].y) / (sum[ed].x - sum[st].x);
    printf("%f\n", res);
    return 0;
}
```

8.2 Painter

```
#include<bits/stdc++.h>
using namespace std;
#define F first
#define S second
#define PB push_back
#define IOS ios_base::sync_with_stdio(0); cin.tie(0);
#define SZ(x) ((int)((x).size()))
#define ALL(x) begin(x),end(x)
#define REP(i,x) for (int i=0; i<(x); i++)
#define REPI(i,a,b) for (int i=(a); i<=(b); i++)

typedef long long ll;
typedef pair<ll,ll> pll;

typedef pll Point;
const int MXN = 100005;

Point operator + (const Point &a, const Point &b) {
    return Point(a.F+b.F, a.S+b.S); }
Point operator - (const Point &a, const Point &b) {
    return Point(a.F-b.F, a.S-b.S); }
ll operator * (const Point &a, const Point &b) { return
    a.F*b.F + a.S*b.S; }
ll operator % (const Point &a, const Point &b) { return
    a.F*b.S - a.S*b.F; }
```

```
struct Segment {
    int v,id;
    Point p,q;
    Segment () {}
    Segment (int _v, int _id, Point _p, Point _q) :
        v(_v), id(_id), p(_p), q(_q) {}
};

bool operator < (const Segment &a, const Segment &b) {
    if (a.p == b.q) return false;
    if (a.q == b.p) return true;
    if (a.p == b.p) return (a.q-a.p) % (b.q-a.p) > 0;
    if (a.q == b.q) return (a.p-a.q) % (b.p-a.q) < 0;
    if (a.p.F == b.p.F) return a.p.S < b.p.S;
    if (a.q.F == b.q.F) return a.q.S < b.q.S;
```



```

    if (a.p.F < b.p.F) return (a.q-a.p) % (b.p-a.p) > 0;
    else return (b.q-b.p) % (a.p-b.p) < 0;
}
bool operator == (const Segment &a, const Segment &b) {
    return tie(a.v,a.id,a.p,a.q) == tie(b.v,b.id,b.p,b.q)
        ;
}
struct Triangle {
    Point pt[3];
}ip[MXN];

const int MEM = 350004;
struct Treap {
    static Treap nil, mem[MEM], *pmem;
    Treap *l, *r;
    int sum,presum,size;
    Segment seg;
    Treap () : l(&nil), r(&nil), sum(0), presum(0), size
        (0), seg() {}
    Treap (Segment _val) :
        l(&nil), r(&nil), sum(_val.v), presum(max(_val.v,0)
        ), size(1), seg(_val) {}
} Treap::nil, Treap::mem[MEM], *Treap::pmem = Treap::
    mem;

int size(const Treap *t) { return t->size; }
void pull(Treap *t) {
    if (!size(t)) return;
    t->size = size(t->l) + size(t->r) + 1;
    t->sum = t->l->sum + t->seg.v + t->r->sum;
    t->presum = max(t->l->presum, t->l->sum + t->seg.v);
    t->presum = max(t->presum, t->l->sum + t->seg.v + t->
        r->presum);
}
Treap* merge(Treap *a, Treap *b) {
    if (!size(a)) return b;
    if (!size(b)) return a;
    Treap *t;
    if (rand() % (size(a) + size(b)) < size(a)) {
        t = a;
        t->r = merge(a->r, b);
    } else {
        t = b;
        t->l = merge(a, b->l);
    }
    pull(t);
    return t;
}
void split(Treap *t, int k, Treap *&a, Treap *&b) {
    if (!size(t)) a = b = &Treap::nil;
    else if (size(t->l) + 1 <= k) {
        a = t;
        split(t->r, k - size(t->l) - 1, a->r, b);
        pull(a);
    } else {
        b = t;
        split(t->l, k, a, b->l);
        pull(b);
    }
}
int get_rank(Treap *t, Segment x) {
    if (!size(t)) return 0;
    if (x < t->seg) return get_rank(t->l, x);
    return get_rank(t->r, x) + size(t->l) + 1;
}
Treap* find_leftist(Treap *t) {
    while (size(t->l)) t = t->l;
    return t;
}
Treap* find_rightist(Treap *t) {
    while (size(t->r)) t = t->r;
    return t;
}

int N;
vector<int> allx;
vector<Segment> _seg[3*MXN];
#define seg(x) _seg[(x)+1000000]

inline void add_seg(Segment s) {
    seg(s.p.F).PB(s);
    if (s.q.F != s.p.F) seg(s.q.F).PB(s);
}

```

```

}
void predo() {
    allx.clear();
    REP(i,N) REP(j,3) {
        seg(ip[i].pt[j].F).clear();
        allx.PB(ip[i].pt[j].F);
    }
    sort(ALL(allx));
    allx.resize(unique(ALL(allx))-begin(allx));
    REP(i,N) {
        sort(ip[i].pt, ip[i].pt+3);
        Point *pt = ip[i].pt;
        Segment seg1 = Segment(1,i,pt[0],pt[1]);
        Segment seg2 = Segment(1,i,pt[0],pt[2]);
        Segment seg3 = Segment(1,i,pt[1],pt[2]);
        if (seg2 < seg1) seg1.v = -1;
        else seg2.v = -1;
        seg3.v = seg1.v;
        add_seg(seg1);
        add_seg(seg2);
        add_seg(seg3);
    }
}
inline int sgn(ll x) { return x < 0 ? -1 : x > 0; }
bool interPnt(Point p1, Point p2, Point q1, Point q2){
    ll c1 = (p2-p1)%(q1-p1), c2 = (p2-p1)%(q2-p1);
    ll c3 = (q2-q1)%(p1-q1), c4 = (q2-q1)%(p2-q1);
    return sgn(c1) * sgn(c2) <= 0 and sgn(c3) * sgn(c4)
        <= 0;
}
bool check_error(Segment a, Segment b) {
    if (a.id == b.id) return false;
    return interPnt(a.p,a.q,b.p,b.q);
}
int solve() {
    Treap::pmem = Treap::mem;
    Treap *rt = &Treap::nil;
    int res = 0;
    for (auto i:allx) {
        for (auto l:seg(i)) {
            int k = get_rank(rt, l);
            Treap *t,*tl,*tm,*tr;
            split(rt,k,tl,tr);
            t = find_rightist(tl);
            if (size(t) and check_error(t->seg,l)) return -1;
            t = find_leftist(tr);
            if (size(t) and check_error(t->seg,l)) return -1;
            rt = merge(tl,tr);
            if (l.p.F == i and l.p.F != l.q.F) {
                k = get_rank(rt, l);
                split(rt,k,tl,tr);
                tm = new (Treap::pmem++) Treap(l);
                rt = merge(merge(tl,tm),tr);
            }
        }
        for (auto l:seg(i)) {
            if (l.q.F == i and l.p.F != l.q.F) {
                Treap *tl,*tm,*tr;
                int k = get_rank(rt, l);
                split(rt,k-1,tl,tm);
                split(tm,1,tm,tr);
                Treap *t1=find_rightist(tl),*t2=find_leftist(tr
                    );
                if (size(t1) and size(t2) and check_error(t1->
                    seg,t2->seg)) return -1;
                rt = merge(tl,tr);
            }
        }
        res = max(res, rt->presum);
    }
    res++;
    return res;
}
int main() {
    IOS;
    int cas = 0;
    while (cin >> N) {
        if (N == -1) break;
        REP(i,N) {
            REP(j,3) cin >> ip[i].pt[j].F >> ip[i].pt[j].S;
        }
        predo();
    }
}

```

```

    int ans = solve();
    cas++;
    cout << "Case " << cas << ": ";
    if (ans == -1) cout << "ERROR\n";
    else cout << ans << " shades\n";
}

return 0;
}

```

8.3 Mo-Algorithm on Tree

```

//bcw0x1bd2 {{{
#include<bits/stdc++.h>
#include<unistd.h>
using namespace std;
#define F first
#define S second
#define MP make_pair
#define PB push_back
#define IOS ios_base::sync_with_stdio(0); cin.tie(0);
#define SZ(x) ((int)((x).size()))
#define ALL(x) begin(x),end(x)
#define REP(i,x) for (int i=0; i<(x); i++)
#define REP1(i,a,b) for (int i=(a); i<=(b); i++)

typedef long long ll;
typedef pair<int,int> pii;
typedef pair<ll,ll> pll;
typedef long double ld;

#ifdef DARKHH
#define FILEIO(name)
#else
#define FILEIO(name) \
    freopen(name".in", "r", stdin); \
    freopen(name".out", "w", stdout);
#endif

#ifdef DARKHH
template<typename> Iter>
ostream& _out(ostream &s, Iter b, Iter e) {
    s << "[ ";
    for (auto it=b; it!=e; it++) s << *it << " ";
    s << "]";
    return s;
}

template<typename A, typename B>
ostream& operator << (ostream &s, const pair<A,B> &p) {
    return s<<"("<<p.first<<","<<p.second<<")"; }

template<typename T>
ostream& operator << (ostream &s, const vector<T> &c) {
    return _out(s,ALL(c)); }

template<typename T, size_t N>
ostream& operator << (ostream &s, const array<T,N> &c) {
    { return _out(s,ALL(c)); } }

template<typename T>
ostream& operator << (ostream &s, const set<T> &c) {
    return _out(s,ALL(c)); }

template<typename A, typename B>
ostream& operator << (ostream &s, const map<A,B> &c) {
    return _out(s,ALL(c)); }
#endif
// }}}
// Let's Fight! ~OAO~~

const int MX = 500005;
const int SQ = 1400;
const int LOG = 17;

struct BIT {
    int bit[MX];
    int lb(int x) { return x & -x; }
    void add(int p, int v) {
        p++;
        for (int i=p; i<MX; i+=lb(i))
            bit[i] += v;
    }
    int qry() {
        int v = 0;

```

```

        for (int i=1<<LOG; i>0; i>>=1) {
            if ((v|i) < MX and bit[v|i]==i) v |= i;
        }
        return v;
    }
}bit;

struct Query {
    int l,r,qid;
}qry[MX];
struct Edge {
    int v,x;
};

int N,Q,timestamp[MX],ans[MX];
int in[MX],cnt[MX];
vector<Edge> E[MX];
vector<Edge> seq;

void DFS(int u, int f) {
    timestamp[u] = SZ(seq);
    for (auto it:E[u]) {
        if (it.v == f) continue;
        seq.PB(it);
        DFS(it.v,u);
        seq.PB(it);
    }
}

void poke(int id) {
    int v = seq[id].v;
    int x = seq[id].x;
    in[v] ^= 1;
    cnt[x] += in[v] ? 1 : -1;
    if (in[v] and cnt[x] == 1) bit.add(x, 1);
    if (!in[v] and cnt[x] == 0) bit.add(x, -1);
}

int main() {
    IOS;
    cin >> N >> Q;
    REP(_,N-1) {
        int u,v,x;
        cin >> u >> v >> x;
        x = min(x,N);
        E[u].PB({v,x});
        E[v].PB({u,x});
    }
    DFS(1,1);
    REP1(i,1,Q) {
        int u,v;
        cin >> u >> v;
        int l = timestamp[u], r = timestamp[v];
        if (l > r) swap(l,r);
        r--;
        qry[i] = {l,r,i};
    }
    sort(qry+1,qry+1+Q, [](Query a, Query b) {
        return make_pair(a.l/SQ,a.r) < make_pair(b.l/SQ,b.r);
    });

    int curL = 1, curR = 0;
    REP1(i,1,Q) {
        int ql=qry[i].l,qv=qry[i].r;
        while (curL > ql) poke(--curL);
        while (curR < qv) poke(++curR);
        while (curL < ql) poke(curL++);
        while (curR > qv) poke(curR--);
        ans[qry[i].qid] = bit.qry();
    }

    REP1(i,1,Q) {
        cout << ans[i] << "\n";
    }

    return 0;
}

```

9 YAKELI

9.1 Periodic Table

1 IA																		18 VIIA																														
1	H	2 IIA																18 VIIA																														
3	Li	4	Be															13 IIIA				14 IVA				15 VA				16 VIA				17 VIIA				Helium										
11	Lithium	12	Beryllium															5	B	6	C	7	N	8	O	9	F	10	Ne																			
19	Na	20	Mg	3 IIIA														13	Al	14	Si	15	P	16	S	17	Cl	18	Ar																			
37	K	38	Ca	39	Sc	40	Ti	41	V	42	Cr	43	Mn	44	Fe	45	Co	46	Ni	47	Cu	48	Zn	49	Ga	50	Ge	51	As	52	Se	53	Br	54	Kr													
55	Rb	56	Sr	57	Y	58	Zr	59	Nb	60	Mo	61	Tc	62	Ru	63	Rh	64	Pd	65	Ag	66	Cd	67	In	68	Sn	69	Sb	70	Te	71	I	72	Xe													
73	Rubidium	74	Strontium	75	Yttrium	76	Zirconium	77	Niobium	78	Molybdenum	79	Technetium	80	Ruthenium	81	Rhodium	82	Palladium	83	Silver	84	Cadmium	85	Indium	86	Tin	87	Antimony	88	Tellurium	89	Iodine	90	Xenon													
87	Fr	88	Ra	89	Ac-Lr	90	Rf	91	Db	92	Sg	93	Bh	94	Hs	95	Mt	96	Ds	97	Rg	98	Cn	99	Uut	100	Fl	101	Uup	102	Lv	103	Uus	104	Uuo													
101	Francium	102	Radium	103	Actinide	104	Rutherfordium	105	Dubnium	106	Seaborgium	107	Bohrium	108	Hassium	109	Meitnerium	110	Darmstadtium	111	Roentgenium	112	Copernicium	113	Uut	114	Fl	115	Uup	116	Lv	117	Uus	118	Uuo													
<div><input type="checkbox"/> Alkali Metal</div> <div><input type="checkbox"/> Alkaline Earth Metal</div> <div><input type="checkbox"/> Metal</div> <div><input type="checkbox"/> Metalloid</div> <div><input type="checkbox"/> Nonmetal</div> <div><input type="checkbox"/> Halogen</div> <div><input type="checkbox"/> Noble Gas</div> <div><input type="checkbox"/> Lanthanide/Actinide</div>																																																
z	mass	man-made																89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr	
	Name																	Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lavrencium																