

Contents

1 Basic	1
1.1 .vimrc	1
1.2 IncreaseStackSize	1
1.3 Default Code	1
2 Data Structure	2
2.1 Bigint	2
2.2 Leftist Heap	2
2.3 extc_balance_tree	3
2.4 Treap	3
2.5 Heavy Light Decomposition	3
3 Graph	4
3.1 Tarjan	4
3.2 Strongly Connected Components:Kosaraju's Algorithm	4
3.3 DMST_with_sol	5
3.4 Maximum Clique	5
3.5 (+1) MinimumMeanCycle	6
4 Flow	6
4.1 ISAP	6
4.2 Dinic	6
4.3 Bipartite Matching (Augmenting Path)	7
4.4 SW-Mincut	7
4.5 Maximum Simple Graph Matching	7
4.6 2-Commodity Flow	8
4.7 (+1) SwGeneralGraphMaxMatching	9
4.8 (+1) SW-mincut $O(NM)$	10
5 Math	10
5.1 ax+by=gcd	10
5.2 Chinese Remainder	10
5.3 Miller Rabin	11
5.4 Mod	11
5.5 Primes	11
5.6 Gauss Elimination	11
5.7 (+1) PolynomialGenerator	11
5.8 Fast Fourier Transform	12
6 Geometry	12
6.1 Point operators	12
6.2 Intersection of two circles	12
6.3 Intersection of two lines	12
6.4 Half Plane Intersection	12
6.5 Point Class	13
6.6 Convex Hull	13
6.7 Minimum Covering Circle	14
6.8 (+1) KDTreeAndNearestPoint	14
6.9 (+1) MinkowskiSum	15
7 Stringology	15
7.1 Suffix Array	15
7.2 Suffix Array (SAIS TWT514)	16
7.3 Aho-Corasick Algorithm	16
7.4 Z value	16
7.5 Z value (palindrome ver.)	17
7.6 Suffix Automaton	17
8 Problems	17
8.1 Find the maximum tangent (x,y is increasing)	17
8.2 cot4	17

1.2 IncreaseStackSize

```

1 //stack resize
1 asm( "mov %0,%esp\n" ::"g"(mem+10000000) );
1 //change esp to rsp if 64-bit system
1
2 //stack resize (linux)
2 #include <sys/resource.h>
2 void increase_stack_size() {
2     const rlim_t ks = 64*1024*1024;
2     struct rlimit rl;
2     int res=getrlimit(RLIMIT_STACK, &rl);
2     if(res==0){
2         if(rl.rlim_cur<ks){
2             rl.rlim_cur=ks;
2             res=setrlimit(RLIMIT_STACK, &rl);
2         }
2     }
2 }

```

1.3 Default Code

```

9 #include<bits/stdc++.h>
10 #include<cmath>
10 #include<cstdio>
10 #include<cstring>
10 #include<cstdlib>
11 #include<iostream>
11 #include<algorithm>
11 #include<vector>
11 using namespace std;
11 #define _SZ(n) memset((n),0,sizeof(n))
11 #define _SMO(n) memset((n),-1,sizeof(n))
12 #define _MC(n,m) memcpy((n),(m),sizeof(n))
12 #define _F first
12 #define _S second
12 #define _MP make_pair
12 #define _PB push_back
13 #define FOR(x,y) for(__typeof(y.begin())x=y.begin();x!=
13 y.end();x++)
13 #define IOS ios_base::sync_with_stdio(0); cin.tie(0)
13 // Let's Fight!
15
15 int main()
15 {
16     return 0;
16 }

```

1 Basic

1.1 .vimrc

```

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

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>

```

2 Data Structure

2.1 Bigint

```
const int bL = 1000;
const int bM = 10000;

struct Bigint{
    int v[bL],l;
    Bigint(){ memset(v, 0, sizeof(v));l=0; }

    void n(){
        for(;l;l--) if(v[l-1]) return;
    }

    Bigint(long long a){
        for(l=0;a;v[l++]=a%bM,a/=bM);
    }
    Bigint(char *a){
        l=0;
        int t=0,i=strlen(a),q=1;
        while(i){
            t+=(a[--i]-'0')*q;
            if((q*=10)>=bM) {
                v[l++]=t; t=0; q=1;
            }
        }
        if(t) v[l++]=t;
    }

    void prt() {
        if(l==0){ putchar('0');return; }
        printf("%d",v[l-1]);
        for(int i=l-2;i>=0;i--) printf("%.4d",v[i]);
    }

    int cp3(const Bigint &b)const {
        if(l!=b.l) return l>b.l?-1:-1;
        for(int i=l-1;i>=0;i--)
            if(v[i]!=b.v[i])
                return v[i]>b.v[i]?1:-1;
        return 0;
    }

    bool operator < (const Bigint &b)const{ return cp3(b)==-1; }
    bool operator == (const Bigint &b)const{ return cp3(b)==0; }
    bool operator > (const Bigint &b)const{ return cp3(b)==1; }

    Bigint operator + (const Bigint &b) {
        Bigint r;
        r.l=max(l,b.l);
        for(int i=0;i<r.l;i++) {
            r.v[i]=v[i]+b.v[i];
            if(r.v[i]>=bM) {
                r.v[i+1]+=r.v[i]/bM;
                r.v[i]%=bM;
            }
        }
        if(r.v[r.l]) r.l++;
        return r;
    }

    Bigint operator - (const Bigint &b) {
        Bigint r;
        r.l=l;
        for(int i=0;i<l;i++) {
            r.v[i]=v[i];
            if(i<b.l) r.v[i]-=b.v[i];
            if(r.v[i]<0) {
                r.v[i]+=bM;
                r.v[i+1]--;
            }
        }
        r.n();
        return r;
    }
}
```

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

Bigint operator / (const Bigint &b) {
    Bigint r;
    r.l=max(1,l-b.l+1);
    for(int i=r.l-1;i>=0;i--) {
        int d=0,u=bM-1,m;
        while(d<u) {
            m=(d+u)>>1;
            r.v[i]=m;
            if((r*b)>(*this)) u=m-1;
            else d=m;
        }
        r.v[i]=d;
    }
    r.n();
    return r;
}

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

2.2 Leftist Heap

```
const int MAXSIZE = 10000;

class Node{
public:
    int num,lc,rc;
    Node () : num(0), lc(-1), rc(-1) {}
    Node (int _v) : num(_v), lc(-1), rc(-1) {}
}tree[MAXSIZE];

int merge(int x, int y){
    if (x == -1) return y;
    if (y == -1) return x;
    if (tree[x].num < tree[y].num)
        swap(x, y);
    tree[x].rc = merge(tree[x].rc, y);
    swap(tree[x].lc, tree[x].rc);
    return x;
}

/* Usage
merge: root = merge(x, y)
delmin: root = merge(root.lc, root.rc)
*/
```

2.3 extc_balance_tree

```
#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);
}
```

2.4 Treap

```
class Node{
public:
    int pri,num,cnt,lc,rc;
    Node () : pri(-1), num(0), cnt(0), lc(0), rc(0) {}
    Node (int _num){
        pri = (rand()<<15) + rand();
        num = _num;
        cnt = 1;
        lc = rc = 0;
    }
}tree[MX];

int nMem;

int get_rand(){
    return (rand()<<15) + rand();
}

int get_node(){
    tree[nMem] = Node();
    if (nMem >= MX) while(1);
    return nMem++;
}

void upd_node(int rt){
    if (!rt) return ;
    int lc=tree[rt].lc;
    int rc=tree[rt].rc;
    tree[rt].cnt = tree[lc].cnt + tree[rc].cnt + 1;
}

int merge(int a, int b){
    if (!a) return b;
    if (!b) return a;
    int res=0;
    if (tree[a].pri > tree[b].pri){
        res = a; //get_node();
        tree[res] = tree[a];
        tree[res].rc = merge(tree[res].rc,b);
    } else {
        res = b; //get_node();
        tree[res] = tree[b];
        tree[res].lc = merge(a,tree[res].lc);
    }
    upd_node(res);
    return res;
}
```

```
pair<int,int> split(int a, int k){
    if (k == 0) return _MP(0,a);
    if (k == tree[a].cnt) return _MP(a,0);
    int lc=tree[a].lc, rc=tree[a].rc;
    pair<int,int> res;
    int np=a; //get_node();
    //tree[np] = tree[a];
    if (tree[lc].cnt >= k){
        res = split(lc,k);
        tree[np].lc = res._S;
        res._S = np;
    } else {
        res = split(rc,k-tree[lc].cnt-1);
        tree[np].rc = res._F;
        res._F = np;
    }
    upd_node(res._F);
    upd_node(res._S);
    return res;
}
```

2.5 Heavy Light Decomposition

```
int N, ip[MX];
int fa[MX],at[MX],belong[MX];
int fr,bk,sz[MX],que[MX];
vector<int> E[MX];

struct Chain{
    int n;
    vector<int> vec;
    vector<int> tree;

    void init(){
        n = vec.size();
        for (int i=0; i<n; i++){
            at[vec[i]] = i;
            tree.resize(4*n);
        }
    }
    void build_tree(int l, int r, int id){
        // Segment Tree
    }
}chain[MX];

void DFS(int u){
    Chain &c = chain[belong[u]];
    c.init();
    for (int i=0; i<c.n; i++){
        u = c.vec[i];
        for (auto v : E[u]){
            if (fa[u] == v || (i && v == c.vec[i-1]))
                continue;
            DFS(v);
        }
    }
    c.build_tree(0,c.n-1,0);
}

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

```

vector<int> get_path(int u){
    vector<int> res;
    while (u){
        res._PB(belong[u]);
        u = fa[chain[belong[u]].vec.back()];
    }
    return res;
}
int jump_chain(int a){
    if (a == 0) return a;
    return fa[chain[belong[a]].vec.back()];
}
pair<int,int> findLCA(int u, int v){
    // at chain res.second
    // jump from u if res.first = 1 ( u -> * res.second )
    // jump from v if res.first = 2 ( v -> * res.second )
    vector<int> vec1,vec2;
    vec1 = get_path(u);
    vec2 = get_path(v);
    int a=u, b=v;
    for (auto v1 : vec1){
        for (auto v2 : vec2){
            if (v1 == v2)
                return sz[a] >= sz[b] ? _MP(1,a) : _MP(2,b);
            b = jump_chain(b);
        }
        a = jump_chain(a);
    }
    return _MP(0,0);
}
int main(int argc, char** argv){
    scanf("%d", &N);
    for (int i=1; i<=N; i++)
        scanf("%d", &ip[i]);
    for (int i=0; i<N-1; i++){
        int u,v;
        scanf("%d%d", &u, &v);
        E[u]._PB(v);
        E[v]._PB(u);
    }
    build_chain();

    return 0;
}

```

3 Graph

3.1 Tarjan

```

const int MAXV = 101000;

int V, E;
vector<int> el[MAXV];
int dfn[MAXV], low[MAXV], did;
bool ins[MAXV];
stack<int> st;
int scc[MAXV], scn;

void tarjan(int u){
    cout << u << endl;
    dfn[u] = low[u] = ++did;
    st.push(u); ins[u] = true;

    for(int i=0; i<(int)el[u].size(); i++){
        int v = el[u][i];
        if(!dfn[v]){
            tarjan(v);
            low[u] = min(low[u], low[v]);
        }else if(ins[v]){
            low[u] = min(low[u], dfn[v]);
        }
    }

    if(dfn[u] == low[u]){
        int v;
        do{
            v = st.top();
            st.pop();

```

```

        scc[v] = scn;
        ins[v] = false;
    }while(v != u);
    scn ++;
}

void calcscc(){
    did = scn = 0;
    for(int i=0; i<V; i++){
        if(!dfn[i]) tarjan(i);
    }
}

```

3.2 Strongly Connected Components: Kosaraju's Algorithm

Compo-

```

class Scc{
public:
    int n,vst[MAXN];
    int nScc,bln[MAXN];
    vector<int> E[MAXN], rE[MAXN], vc;
    void init(int _n){
        n = _n;
        for (int i=0; i<MAXN; 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(it,E[u]){
            if (!vst[*it])
                DFS(*it);
        }
        vc._PB(u);
    }
    void rDFS(int u){
        vst[u] = 1;
        bln[u] = nScc;
        FOR(it,rE[u]){
            if (!vst[*it])
                rDFS(*it);
        }
    }
    void solve(){
        nScc=0;
        vc.clear();
        _SZ(vst);
        for (int i=0; i<n; i++){
            if (!vst[i])
                DFS(i);
        }
        reverse(vc.begin(),vc.end());
        _SZ(vst);
        FOR(it,vc){
            if (!vst[*it]){
                rDFS(*it);
                nScc++;
            }
        }
    }
};

```

3.3 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(_MP(_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 cycid,incycle[MXN],contracted[MXN];
vector<int> E[MXN];

edge_t dmst(int rt){
    edge_t cost;
    for (int i=0; i<N; i++){
        contracted[i] = 0;
        incycle[i] = 0;
        prv[i] = EDGE_INF;
    }
    cycid = 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;
        incycle[v] = ++cycid;
        for (u=prv[v].u; u!=v; u=prv[u].u){
            contracted[u] = 1;
            incycle[u] = cycid;
        }
        for (int i=0; i<M; i++){

```

```

            if (incycle[eg[i].u] != cycid && incycle[eg
                [i].v] == cycid){
                eg[i] -= prv[eg[i].v];
            }
        }
        for (int i=0; i<M; i++){
            if (incycle[eg[i].u] == cycid) eg[i].u = v;
            if (incycle[eg[i].v] == cycid) 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 && incycle[prv[i].u] ==
                cycid)
                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);
    }
}

```

3.4 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;
        _SZ(el); _SZ(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 ; d++) {
                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;
}
};

```

3.5 (+1) MinimumMeanCycle

```

/* minimum mean cycle */
class Edge { public:
    int v,u;
    double c;
};
int n,m;
Edge e[MAXEDGE];
double d[MAXNUM][MAXNUM];
inline void relax(double &x,double val) { if(val<x) x=
    val; }
inline void bellman_ford() {
    int i,j;
    for(j=0;j<n;j++) d[0][j]=0.0;
    for(i=0;i<n;i++) {
        for(j=0;j<n;j++) d[i+1][j]=inf;
        for(j=0;j<m;j++)
            if(d[i][e[j].v]<inf-eps) relax(d[i+1][e[j].u],d[i]
                ][
                    e[j].v]+e[j].c);
    }
}
inline double karp_mmc() {
    // returns inf if no cycle, mmc otherwise
    int i,k; double mmc=inf,avg;
    bellman_ford();
    for(i=0;i<n;i++) {
        avg=0.0;
        for(k=0;k<n;k++) {
            if(d[n][i]<inf-eps) avg=max(avg,(d[n][i]-d[k][i])
                /(
                    n-k));
            else avg=max(avg,inf);
        }
        mmc=min(mmc,avg);
    }
    return mmc;
}

```

4 Flow

4.1 ISAP

```

class Isap{
public:
    static const int MXN = 10000;
    class Edge{
    public:
        int v,f,re;
        Edge (){ v=f=re=-1; }
        Edge (int _v, int _f, int _r){
            v = _v;
            f = _f;
            re = _r;
        }
    };
};

```

```

int n,s,t,h[MXN],gap[MXN];
vector<Edge> E[MXN];
void init(int _n, int _s, int _t){
    n = _n;
    s = _s;
    t = _t;
    for (int i=0; i<n; i++)
        E[i].clear();
}
void add_edge(int u, int v, int f){
    E[u]._PB(Edge(v,f,E[v].size()));
    E[v]._PB(Edge(u,0,E[u].size()-1));
}
int DFS(int u, int nf, int res=0){
    if (u == t) return nf;
    for (auto &it : E[u]){
        if (h[u]==h[it.v]+1 && it.f>0){
            int tf = DFS(it.v,min(nf,it.f));
            res += tf;
            nf -= tf;
            it.f -= tf;
            E[it.v][it.re].f += tf;
            if (nf == 0) return res;
        }
    }
    if (nf){
        if (--gap[h[u]] == 0) h[s]=n;
        gap[++h[u]]++;
    }
    return res;
}
int flow(int res=0){
    _SZ(h);
    _SZ(gap);
    gap[0] = n;
    while (h[s] < n)
        res += DFS(s,2147483647);
    return res;
}
}flow;

```

4.2 Dinic

```

class Dinic{
public:
    static const int MXN = 10000;
    class Edge{
    public:
        int v,f,re;
        Edge (){ v=f=re=-1; }
        Edge (int _v, int _f, int _r){
            v = _v;
            f = _f;
            re = _r;
        }
    };
    int n,s,t;
    int fr,bk,que[MXN],level[MXN];
    vector<Edge> E[MXN];
    void init(int _n, int _s, int _t){
        n = _n;
        s = _s;
        t = _t;
        for (int i=0; i<n; i++)
            E[i].clear();
    }
    void add_edge(int u, int v, int f){
        E[u]._PB(Edge(v,f,E[v].size()));
        E[v]._PB(Edge(u,0,E[u].size()-1));
    }
    bool BFS(){
        _SMO(level);
        fr = bk = 0;
        que[bk++] = s;
        level[s] = 0;
        while (fr < bk){
            int u = que[fr++];
            for (auto it : E[u]){
                if (it.f > 0 && level[it.v] == -1){
                    level[it.v] = level[u]+1;

```

```

        que[bk++] = it.v;
    }
}
return level[t] != -1;
}
int DFS(int u, int nf){
    if (u == t) return nf;
    int res = 0;
    for (auto &it : E[u]){
        if (it.f > 0 && level[it.v] == level[u]+1){
            int tf = DFS(it.v, min(nf, it.f));
            res += tf; nf -= tf; it.f -= tf;
            E[it.v][it.re].f += tf;
            if (nf == 0) return res;
        }
    }
    if (!res) level[u] = -1;
    return res;
}
int flow(int res=0){
    while (BFS())
        res += DFS(s, 2147483647);
    return res;
}
}
}flow;

```

4.3 Bipartite Matching (Augmenting Path)

```

bool DFS(int u){
    for (auto v : E[u]){
        if (!vst[v]){
            vst[v]=1;
            if (match[v] == -1 || DFS(match[v])){
                match[v] = u;
                match[u] = v;
                return true;
            }
        }
    }
    return false;
}
int DoMatch(int res=0){
    memset(match, -1, sizeof(match));
    for (int i=1; i<=N; i++){
        if (match[i] == -1){
            memset(vst, 0, sizeof(vst));
            DFS(i);
        }
    }
    for (int i=1; i<=N; i++)
        if (match[i] != -1) res++;
    return res;
}
}

```

4.4 SW-Mincut

```

typedef long long LL;
typedef long double LD;
typedef std::pair<int, int> PII;

const int N=514;
const int INF=2147483647>>1;

int n, m, del[N], vst[N], wei[N], rd[N][N];

PII sw(){
    MSET(vst, 0);
    MSET(wei, 0);
    int p1=-1, p2=-1, mx, cur=0;
    while(1){
        mx=-1;
        REP(i, 1, n){
            if (!del[i] && !vst[i] && mx<wei[i]){
                cur=i;
                mx=wei[i];
            }
        }
    }
}

```

```

    if (mx== -1) break;
    vst[cur]=1;
    p1=p2;
    p2=cur;
    REP(i, 1, n)
        if (!vst[i] && !del[i])
            wei[i]+=rd[cur][i];
}
return std::MP(p1, p2);
}
void input(){
    REP(i, 1, n){
        del[i]=0;
        REP(j, 1, n)
            rd[i][j] = 0;
    }
    REP(i, 1, m){
        int u, v, c;
        scanf("%d%d%d", &u, &v, &c);
        ++u; ++v;
        rd[u][v]+=c;
        rd[v][u]+=c;
    }
}
void solve(){
    int ans=INF;
    PII tmp;
    REP(i, 1, n-1){
        tmp=sw();
        int x=tmp.F;
        int y=tmp.S;
        if (wei[y] < ans) ans=wei[y];
        del[y]=1;
        REP(j, 1, n){
            rd[j][x]+=rd[j][y];
            rd[x][j]+=rd[y][j];
        }
    }
    printf("%d\n", ans);
}

int main(){
    while (~scanf("%d%d", &n, &m)){
        input();
        solve();
    }
    return 0;
}

```

4.5 Maximum Simple Graph Matching

```

const int MAXN = 250;

struct GenMatch {
    int V, E;
    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() {
        memset(el, 0, sizeof(el));
        memset(pr, 0, sizeof(pr));
        memset(inq, 0, sizeof(inq));
        memset(inp, 0, sizeof(inp));
        memset(inb, 0, sizeof(inb));
        memset(djs, 0, sizeof(djs));
        memset(bk, 0, sizeof(bk));
        ans = 0;
    }
    void setve(int _v, int _e) {
        V = _v; E = _e;
    }
    void 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();
    gp.setve(V, E);
    for(int i=0; i<E; i++) {
        int u, v;
        cin >> u >> v;
        gp.edge(u, v);
    }
    cout << gp.solve() << endl;
}

```

4.6 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;
}

```

4.7 (+1) SwGeneralGraphMaxMatching

```

#define N 256 // max vertex num
class Graph { public:
    // n, g[i][j]=0/1, match() => match: (i, mate[i]) (or
    // mate[i]=-1)
    int n, mate[N];
    bool g[N][N], inQ[N], inBlo[N];
    queue<int> Q;
    int start, newBase, prev[N], base[N];
    int lca(int u, int v) {
        bool path[N] = { false };
        while(true) {
            u = base[u]; path[u] = true;
            if(u == start) break;
            u = prev[mate[u]];
        }
        while(true) {
            v = base[v];
            if(path[v]) break;
            v = prev[mate[v]];
        }
        return v;
    }
    void trace(int u) {
        while(base[u] != newBase) {
            int v = mate[u];
            inBlo[base[u]] = inBlo[base[v]] = true;
            u = prev[v];
            if(base[u] != newBase) prev[u] = v;
        }
    }
    void contract(int u, int v) {
        newBase = lca(u, v);
        memset(inBlo, false, sizeof(inBlo));
        trace(u); trace(v);
        if(base[u] != newBase) prev[u] = v;
        if(base[v] != newBase) prev[v] = u;
        for(int i = 0; i < n; i++)
            if(inBlo[base[i]]) {
                base[i] = newBase;
                if(!inQ[i]) { Q.push(i); inQ[i] = true; }
            }
    }
    bool search() {
        memset(inQ, false, sizeof(inQ));
        memset(prev, -1, sizeof(prev));
        for(int i = 0; i < n; i++) base[i] = i;
        while(!Q.empty()) Q.pop();
        Q.push(start); inQ[start] = true;
        while(!Q.empty()) {
            int u = Q.front(); Q.pop();
            for(int i = 0; i < n; i++)
                if(g[u][i] && base[u] != base[i] && mate[u] != i) {
                    if(i == start || (mate[i] >= 0 && prev[mate[i]] >= 0)) contract(u, i);
                    else if(prev[i] < 0) {
                        prev[i] = u;
                        if(mate[i] != -1) { Q.push(mate[i]); inQ[mate[i]] = true; }
                        else { augment(i); return true; }
                    }
                }
        }
        return false;
    }
    void augment(int u) {
        while(u >= 0) {
            int v = prev[u], w = mate[v];
            mate[v] = u; mate[u] = v; u = w;
        }
    }
    int match() {
        memset(mate, -1, sizeof(mate));
        int mth = 0;
        for(int i = 0; i < n; i++) {
            if(mate[i] >= 0) continue;
            start = i;
            if(search()) mth++;
        }
    }
}

```

```

    return mth;
}
};

```

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);
        //
        // --8<-----
    }
    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(MP(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(MP(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 Chinese Remainder

```

int pfn; // number of distinct prime factors
int pf[MAXNUM]; // prime factor powers
int rem[MAXNUM]; // corresponding remainder
int pm[MAXNUM];
inline void generate_primes() {
    int i,j;
    pnum=1;
    prime[0]=2;
    for(i=3;i<MAXVAL;i+=2) {
        if(!nprime[i]) continue;
        prime[pnum++]=i;
        for(j=i*i;j<MAXVAL;j+=i) nprime[j]=1;
    }
}
inline int inverse(int x,int p) {
    int q,tmp,a=x,b=p;
    int a0=1,a1=0,b0=0,b1=1;
    while(b) {
        q=a/b; tmp=b; b=a-b*q; a=tmp;
        tmp=b0; b0=a0-b0*q; a0=tmp;
        tmp=b1; b1=a1-b1*q; a1=tmp;
    }
    return a0;
}
inline void decompose_mod() {
    int i,p,t=mod;
    pfn=0;
    for(i=0;i<pnum&&prime[i]<=t;i++) {
        p=prime[i];
        if(t%p==0) {
            pf[pfn]=1;
            while(t%p==0) {
                t/=p;
                pf[pfn]*=p;
            }
            pfn++;
        }
    }
}

```

```

    }
    if(t>1) pf[pfn++]=t;
}
inline int chinese_remainder() {
    int i,m,s=0;
    for(i=0;i<pfn;i++) {
        m=mod/pf[i];
        pm[i]=(long long)m*inverse(m,pf[i])%mod;
        s=(s+(long long)pm[i]*rem[i])%mod;
    }
    return s;
}

```

5.3 Miller Rabin

```

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;
}

```

5.4 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);
}

```

5.5 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
 */

```

5.6 Gauss Elimination

```

const int MAX = 300;
const double EPS = 1e-8;

double mat[MAX][MAX];
void Gauss(int n) {
    for(int i=0; i<n; i++) {
        bool ok = 0;
        for(int j=i; j<n; j++) {
            if(fabs(mat[j][i]) > EPS) {
                swap(mat[j], mat[i]);
                ok = 1;
                break;
            }
        }
        if(!ok) continue;

        double fs = mat[i][i];
        for(int j=i+1; j<n; j++) {
            double r = mat[j][i] / fs;
            for(int k=i; k<n; k++) {
                mat[j][k] -= mat[i][k] * r;
            }
        }
    }
}

```

5.7 (+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;
};
```

5.8 Fast Fourier Transform

```
typedef complex<double> cplx;
const int PI = acos(-1);
const cplx I(0, 1);
void fft(int n, cplx a[]) {
    double theta = 2 * PI / n;
    for (int m = n; m >= 2; m >>= 1) {
        int mh = m >> 1;
        for (int i = 0; i < mh; i++) {
            cplx w = exp(i*theta*I);
            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 *= 2;
    }
    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]);
    }
}
```

6 Geometry

6.1 Point operators

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

#define _x first
#define _y second
typedef pair<double, double> pdd;

pdd operator + (const pdd p1, const pdd p2){
    return pdd(p1._x + p2._x, p1._y + p2._y);
}
pdd operator - (const pdd p1, const pdd p2){
    return pdd(p1._x - p2._x, p1._y - p2._y);
}

pdd operator * (const double c, const pdd p){
    return pdd(p._x * c, p._y * c);
}
pdd operator - (const pdd p){
    return (-1.0) * p;
}
double operator * (const pdd p1, const pdd p2){
    return p1._x * p2._x + p1._y * p2._y;
}
double operator % (const pdd p1, const pdd p2){
    return p1._x * p2._y - p2._x * p1._y;
}
```

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 $d < r_1 + r_2$.

6.3 Intersection of two lines

```
#include<bits/stdc++.h>

using namespace std;
const double EPS = 1e-9;

pdd interPnt(pdd p1, pdd p2, pdd q1, pdd q2){
    double f1 = (p2 - p1) % (q1 - p1);
    double f2 = (p2 - p1) % (p1 - q2);
    double f = (f1 + f2);

    if(fabs(f) < EPS) return pdd(nan(""), nan(""));

    return (f2 / f) * q1 + (f1 / f) * q2;
}
```

6.4 Half Plane Intersection

```
#include<bits/stdc++.h>

using namespace std;

#define _PB push_back
#define _MP make_pair
#define _x first
#define _y second

const int MXL = 5000;
const double EPS = 1e-8;

typedef pair<double, double> pdd;
typedef pair<pdd, pdd> Line;

pdd operator + (const pdd p1, const pdd p2){
    return pdd(p1._x + p2._x, p1._y + p2._y);
}

pdd operator - (const pdd p1, const pdd p2){
    return pdd(p1._x - p2._x, p1._y - p2._y);
}

pdd operator * (const double c, const pdd p){
    return pdd(p._x * c, p._y * c);
}

double operator % (const pdd p1, const pdd p2){
    return p1._x * p2._y - p2._x * p1._y;
}

vector<Line> lnlst;
double atn[MXL];

bool lncmp(int l1, int l2){
    return atn[l1] < atn[l2];
}

pdd interPnt(pdd p1, pdd p2, pdd q1, pdd q2){
    double f1 = (p2 - p1) % (q1 - p1);
    double f2 = (p2 - p1) % (p1 - q2);
    double f = (f1 + f2);

    if(fabs(f) < EPS) return pdd(nan(""), nan(""));

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

deque<Line> dq;
```

```

void halfPlaneInter(){
    int n = ln1st.size();
    vector<int> stlst;
    for(int i=0; i<n; i++){
        stlst._PB(i);
        pdd d = ln1st[i].second - ln1st[i].first;
        atn[i] = atan2(d._y, d._x);
    }
    sort(stlst.begin(), stlst.end(), lncmp);
    vector<Line> lst;

    for(int i=0; i<n; i++){
        if(i) {
            int j = i-1;
            Line li = ln1st[stlst[i]];
            Line lj = ln1st[stlst[j]];
            pdd di = li.second - li.first;
            pdd dj = lj.second - lj.first;
            if(fabs(di%dj) < EPS){
                if(di % (lj.second - li.second) < 0) {
                    lst.pop_back();
                }else continue;
            }
        }
        lst._PB(ln1st[stlst[i]]);

        dq._PB(lst[0]);
        dq._PB(lst[1]);
        for(int i=2; i<n; i++){
            int dsz = dq.size();
            Line l = lst[i];
            while(dsz >= 2){
                Line l1 = dq[dsz-1];
                Line l2 = dq[dsz-2];

                pdd it12 = interPnt(l1.first, l1.second, l2.first,
                    , l2.second);

                if((l.second - l.first) % (it12 - l.first) < 0){
                    dq.pop_back();
                    dsz --;
                } else break;
            }

            while(dsz >= 2){
                Line l1 = dq[0];
                Line l2 = dq[1];

                pdd it12 = interPnt(l1.first, l1.second, l2.first,
                    , l2.second);

                if((l.second - l.first) % (it12 - l.first) < 0){
                    dq.pop_front();
                    dsz --;
                } else break;
            }

            Line l1 = dq[dsz - 1];
            if(!std::isnan(interPnt(l1.first, l1.second, l1.first,
                , l1.second)._x)){
                dq._PB(1);
            }
        }

        int dsz = dq.size();
        while(dsz >= 2){
            Line l1 = dq[dsz - 1];
            Line l2 = dq[dsz - 2];
            Line l = dq[0];
            pdd it12 = interPnt(l1.first, l1.second, l2.first,
                , l2.second);
            if(std::isnan(it12._x)) {
                dq.pop_back();
                dq.pop_back();
                dsz -= 2;
            } else if((l.second - l.first) % (it12 - l.first) <
                0){
                dq.pop_back();
                dsz --;
            }
        }
    }
}

```

```

    } else break;
}

int main(){
    int N;
    cin >> N;
    for(int i=0; i<N; i++){
        double x1, x2, y1, y2;
        cin >> x1 >> y1 >> x2 >> y2;
        ln1st._PB(_MP(pdd(x1, y1), pdd(x2, y2)));
    }

    halfPlaneInter();

    int dsz = dq.size();
    cout << dsz << endl;
    for(int i=0; i<dsz; i++){
        int j = (i+1) % dsz;
        pdd it = interPnt(dq[i].first, dq[i].second, dq[j].
            first, dq[j].second);
        cout << it._x << ' ' << it._y << endl;
    }
}

```

6.5 Point Class

```

struct Point{
    typedef double T;
    T x, y;

    Point() : x(0), y(0) {}
    Point(T _x, T _y) : x(_x), y(_y) {}

    bool operator < (const Point &b) const{
        return tie(x,y) < tie(b.x,b.y);
    }
    bool operator == (const Point &b) const{
        return tie(x,y) == tie(b.x,b.y);
    }
    Point operator + (const Point &b) const{
        return Point(x+b.x, y+b.y);
    }
    Point operator - (const Point &b) const{
        return Point(x-b.x, y-b.y);
    }
    T operator * (const Point &b) const{
        return x*b.x + y*b.y;
    }
    T operator % (const Point &b) const{
        return x*b.y - y*b.x;
    }
    Point operator * (const T &b) const{
        return Point(x*b, y*b);
    }
    T abs(){
        return sqrt(abs2());
    }
    T abs2(){
        return x*x + y*y;
    }
};

```

6.6 Convex Hull

```

double cross(Point o, Point a, Point b){
    return (a-o) % (b-o);
}

vector<Point> convex_hull(vector<Point> pt){
    sort(pt.begin(),pt.end());
    int top=0;
    vector<Point> 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;
}

```

6.7 Minimum Covering Circle

```

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

    void init(int _n, Point _p[]){
        n = _n;
        memcpy(p,_p,sizeof(Point)*n);
    }
    double sqr(double a){ return a*a; }
    Point center(Point p0, Point p1, Point p2) {
        Point a = p1-p0;
        Point b = p2-p0;
        double c1=a.len2()*0.5;
        double c2=b.len2()*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 Point(x,y);
    }

    pair<Point,double> solve(){
        random_shuffle(p,p+n);
        r2=0;
        for (int i=0; i<n; i++){
            if ((cen-p[i]).len2() <= r2) continue;
            cen = p[i];
            r2 = 0;
            for (int j=0; j<i; j++){
                if ((cen-p[j]).len2() <= r2) continue;
                cen = Point((p[i].x+p[j].x)*0.5, (p[i].y+p[j].y)*0.5);
                r2 = (cen-p[j]).len2();
            }
            for (int k=0; k<j; k++){
                if ((cen-p[k]).len2() <= r2) continue;
                cen = center(p[i],p[j],p[k]);
                r2 = (cen-p[k]).len2();
            }
        }
        return _MP(cen,r2);
    }
}mcc;

```

6.8 (+1) KDTreeAndNearestPoint

```

const INF = 1100000000;

class NODE{ public:
    int x,y,x1,x2,y1,y2;
    int i,f;
    NODE *L,*R;
};

inline long long dis(NODE& a,NODE& b){
    long long dx=a.x-b.x;
    long long dy=a.y-b.y;
    return dx*dx+dy*dy;
}

NODE node[100000];
bool cmpx(const NODE& a,const NODE& b){ return a.x<b.x;
}

```

```

bool cmpy(const NODE& a,const NODE& b){ return a.y<b.y;
}

NODE* KDTree(int L,int R,int dep){
    if(L>R) return 0;
    int M=(L+R)/2;
    if(dep%2==0){
        nth_element(node+L,node+M,node+R+1,cmpx);
        node[M].f=0;
    }else{
        nth_element(node+L,node+M,node+R+1,cmpy);
        node[M].f=1;
    }
    node[M].x1=node[M].x2=node[M].x;
    node[M].y1=node[M].y2=node[M].y;
    node[M].L=KDTree(L,M-1,dep+1);
    if(node[M].L){
        node[M].x1=min(node[M].x1,node[M].L->x1);
        node[M].x2=max(node[M].x2,node[M].L->x2);
        node[M].y1=min(node[M].y1,node[M].L->y1);
        node[M].y2=max(node[M].y2,node[M].L->y2);
    }
    node[M].R=KDTree(M+1,R,dep+1);
    if(node[M].R){
        node[M].x1=min(node[M].x1,node[M].R->x1);
        node[M].x2=max(node[M].x2,node[M].R->x2);
        node[M].y1=min(node[M].y1,node[M].R->y1);
        node[M].y2=max(node[M].y2,node[M].R->y2);
    }
    return node+M;
}

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

void nearest(NODE* r,int z,long long &md){
    if(!r || !touch(r,node[z].x,node[z].y,md)) return;
    long long d;
    if(node[z].i!=r->i){
        d=dis(*r,node[z]);
        if(d<md) md=d;
    }
    if(r->f==0){
        if(node[z].x<r->x){
            nearest(r->L,z,md);
            nearest(r->R,z,md);
        }else{
            nearest(r->R,z,md);
            nearest(r->L,z,md);
        }
    }else{
        if(node[z].y<r->y){
            nearest(r->L,z,md);
            nearest(r->R,z,md);
        }else{
            nearest(r->R,z,md);
            nearest(r->L,z,md);
        }
    }
}

int main(){
    int TT,n,i;
    long long d;
    NODE* root;
    scanf("%d",&TT);
    while(TT--){
        scanf("%d",&n);
        for(i=0;i<n;i++){
            scanf("%d %d",&node[i].x,&node[i].y);
            node[i].i=i;
        }
        root=KDTree(0,n-1,0);
        for(i=0;i<n;i++){
            d=900000000000000000LL;
            nearest(root,i,d);
            ans[node[i].i]=d;
        }
    }
}

```

6.9 (+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+2;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[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]]);
    }
};

int main(){
    // s is int array
    SA *sa = new SA();
    sa->build(s,n,128);
}

```

7.3 Aho-Corasick Algorithm

```

class AAutomata{
public:
    class Node{
    public:
        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 Z value

```

char s[MAXLEN];
int len,z[MAXLEN];
void Z_value() {
    int i,j,left,right;
    left=right=0; z[0]=len;
    for(i=1;i<len;i++) {
        j=max(min(z[i-left],right-i),0);
        for(;i+j<len&&s[i+j]==s[j];j++);
        z[i]=j;
        if(i+z[i]>right) {
            right=i+z[i];
            left=i;
        }
    }
}

```


7.5 Z value (palindrome ver.)

```
const int MAX = 1000;
int len;
char ip[MAX];
char op[MAX*2];
int zv[MAX*2];

int main(){
    cin >> ip;
    len = strlen(ip);

    int l2 = len*2 - 1;
    for(int i=0; i<l2; i++){
        if(i&1) op[i] = '@';
        else op[i] = ip[i/2];
    }
    int l=0, r=0;
    zv[0] = 1;

    for(int i=1; i<l2; i++){
        if( i > r ){
            l = r = i;
            while( l>0 && r<l2-1 && op[l-1] == op[r+1] ){
                l--;
                r++;
            }
            zv[i] = (r-l+1);
        }else{
            int md = (l+r)/2;
            int j = md + md - i;
            zv[i] = zv[j];
            int q = zv[i] / 2;
            int nr = i + q;
            if( nr == r ){
                l = i + i - r;

                while( l>0 && r<l2-1 && op[l-1] == op[r+1] ){
                    l--;
                    r++;
                }
                zv[i] = r - l + 1;
            }else if( nr > r ){
                zv[i] = (r - i) * 2 + 1;
            }
        }
    }

    return 0;
}
```

7.6 Suffix Automaton

```
class SAM{ //SuffixAutomaton
public:
    class State{
    public:
        State *par, *go[26];
        int val;
        State (int _val) :
            par(0), val(_val){
            MSET(go,0);
        }
    };
    State *root, *tail;

    void init(const string &str){
        root = tail = new State(0);
        for (int i=0; i<SZ(str); i++){
            extend(str[i]-'a');
        }
    }
    void extend(int w){
        State *p = tail, *np = new State(p->val+1);
        for ( ; p && p->go[w]==0; p=p->par)
            p->go[w] = np;
        if (p == 0){
            np->par = root;
        } else {

```

```
if (p->go[w]->val == p->val+1){
    np->par = p->go[w];
} else {
    State *q = p->go[w], *r = new State(0);
    *r = *q;
    r->val = p->val+1;
    q->par = np->par = r;
    for ( ; p && p->go[w]==q; p=p->par)
        p->go[w] = r;
    }
}
tail = np;
}
};
```

8 Problems

8.1 Find the maximum 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 - 1; 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+1]))
            now++;
        calc = sum[i+1] - pnt[now-1];
        if (ans.y * calc.x < ans.x * calc.y){
            ans = calc;
            st = pnt[now-1].x;
            ed = i + 1;
        }
    }
    double res = (sum[ed].y-sum[st].y)/(sum[ed].x-sum[st].x);
    printf("%f\n", res);
    return 0;
}
```

8.2 cot4

```
#include <bits/stdc++.h>
using namespace std;
#define _SZ(n) memset((n),0,sizeof(n))
#define _SMO(n) memset((n),-1,sizeof(n))
```

```

#define _MC(n,m) memcpy((n),(m),sizeof(n))
#define _F first
#define _S second
#define _MP make_pair
#define _PB push_back
#define FOR(x,y) for(__typeof(y.begin())x=y.begin();x!=
    y.end();x++)
#define IOS ios_base::sync_with_stdio(0)

#ifdef ONLINE_JUDGE
#define FILEIO(name) \
    freopen(name".in", "r", stdin); \
    freopen(name".out", "w", stdout);
#else
#define FILEIO(name)
#endif
// Let's Fight!

typedef long long LL;

const int MXN = 130005;
const int MX = 300005;
const int HASH = 12721;
const int MOD = 999997771;
const int LOG = 17;
struct query_t{
    int ti,sj,id;
};
struct tTree_t{
    int tp, prvID, prvID2;
    char ch;
    int l,r,len;
}tTree[MXN];
vector<int> E[MXN];
vector<query_t> q[MXN];

int sa[MXN],rk[MXN],rk2[MXN],fa[LOG][MXN],sCh[MXN],
    cmpLv;
pair<int,int> azRange[30];
int N,nq;
int tID,sID;
int ans[MXN];

inline int getRank(int id){
    if (id == 0) return 0;
    if (id >= sID) while(1);
    return rk[id];
}
bool comp0(int a, int b){
    return sCh[a] < sCh[b];
}
bool comp1(int a, int b){
    if (getRank(a) == getRank(b)){
        return getRank(fa[cmpLv][a]) < getRank(fa[cmpLv][b]);
    }
    return getRank(a) < getRank(b);
}
void suffix_array(){
    sCh[1] = 0;
    for (int i=1; i<sID; i++){
        sa[i] = i;
        rk[i] = sCh[i];
    }
    sort(sa+1,sa+sID,comp0);
    cmpLv = 0;
    for (int len = 1; len < MXN; len <= 1){
        sort(sa+1,sa+sID,comp1);
        int r = 1;
        rk2[sa[1]] = r;
        for (int i=2; i<sID; i++){
            if (comp1(sa[i-1],sa[i])){
                rk2[sa[i]] = ++r;
            } else {
                rk2[sa[i]] = r;
            }
        }
        for (int i=1; i<sID; i++){
            rk[i] = rk2[i];
        }
        cmpLv++;
    }
}

```

```

}

void init(){
    nq = 0;
    tID = 2;
    sID = 2;
    _SZ(fa);
}
int trash;
void input(){
    init();
    trash = scanf("%d", &N);
    for (int i=0; i<N; i++){
        int cmd;
        trash = scanf("%d", &cmd);
        if (cmd == 1){
            int prvID;
            char str[10];
            trash = scanf("%d%s", &prvID, str);
            E[prvID]._PB(sID);
            fa[0][sID] = prvID;
            sCh[sID] = str[0];
            sID++;
        } else if (cmd == 2){
            int dir;
            int prvID;
            char str[5];
            trash = scanf("%d%d%s", &dir,&prvID,str);
            if (dir == 0){
                tTree[tID].tp = 0;
                tTree[tID].prvID = prvID;
                tTree[tID++].ch = str[0];
            } else {
                tTree[tID].tp = 1;
                tTree[tID].prvID = prvID;
                tTree[tID++].ch = str[0];
            }
        } else if (cmd == 3){
            int a,b;
            trash = scanf("%d%d", &a, &b);
            tTree[tID].tp = 2;
            tTree[tID].prvID = a;
            tTree[tID++].prvID2 = b;
        } else if (cmd == 4){
            int ti,sj;
            trash = scanf("%d%d", &ti, &sj);
            q[sj]._PB((query_t){ti,sj,nq});
            nq++;
        }
    }
}
int moveUP(int u, int len){
    for (int i=0; i<LOG && len; i++){
        if (len & (1<<i)){
            len -= 1<<i;
            u = fa[i][u];
        }
    }
    return u;
}
int getL(int l, int r, int up, int cp){
    if (l == r) return l;
    while (l < r){
        int mid = (l+r) / 2;
        int id = moveUP(sa[mid],up);
        if (cp <= rk[id])
            r = mid;
        else
            l = mid+1;
    }
    return l;
}
int getR(int l, int r, int up, int cp){
    if (l == r) return l;
    while (l < r){
        int mid = (l+r) / 2;
        int id = moveUP(sa[mid],up);
        if (cp < rk[id])
            r = mid;
        else
            l = mid+1;
    }
}

```

```

    return 1;
}
void prvSolve(){
    for (int i=1; i<LOG; i++){
        for (int j=1; j<sID; j++){
            fa[i][j] = fa[i-1][fa[i-1][j]];
        }
    }
    suffix_array();
    for (int i=0; i<30; i++){
        azRange[i] = _MP(sID,0);
    }
    for (int i=1; i<sID; i++){
        if (sa[i] == 1) continue;
        int ch = sCh[sa[i]] - 'a';
        azRange[ch]._F = min(azRange[ch]._F,i);
        azRange[ch]._S = max(azRange[ch]._S,i);
    }
    for (int i=0; i<30; i++){
        azRange[i]._S++;
        if (azRange[i]._S == 1){
            azRange[i]._F = azRange[i]._S = sID;
        }
    }

    tTree[1].len = 0;
    tTree[1].l = 1;
    tTree[1].r = sID;
    for (int i=2; i<tID; i++){
        int id1 = tTree[i].prvID;
        int id2 = tTree[i].prvID2;
        if (tTree[i].tp == 0){
            tTree[i].len = tTree[id1].len + 1;
            int up = tTree[id1].len;
            char ch = tTree[i].ch;
            int l,r;
            l = tTree[id1].l;
            r = tTree[id1].r;
            if (l == r){
                tTree[i].l = tTree[i].r = 1;
            } else {
                while (l < r){
                    int mid = (l+r)/2;
                    int id = moveUP(sa[mid],up);
                    if (ch <= sCh[id])
                        r = mid;
                    else
                        l = mid+1;
                }
                tTree[i].l = 1;

                l = tTree[id1].l;
                r = tTree[id1].r;
                while (l < r){
                    int mid = (l+r)/2;
                    int id = moveUP(sa[mid],up);
                    if (ch < sCh[id])
                        r = mid;
                    else
                        l = mid+1;
                }

                tTree[i].r = r;
            }
        } else if (tTree[i].tp == 1){
            tTree[i].len = tTree[id1].len + 1;
            int ch = tTree[i].ch;
            int l = azRange[ch-'a']._F;
            int r = azRange[ch-'a']._S;
            if (id1 == 1){
                tTree[i].l = 1;
                tTree[i].r = r;
            } else {
                tTree[i].l = getL(l,r,1,tTree[id1].l);
                tTree[i].r = getR(l,r,1,tTree[id1].r-1);
            }
        } else if (tTree[i].tp == 2){
            tTree[i].len = tTree[id1].len + tTree[id2].len;
            tTree[i].len = min(tTree[i].len,100005);
            if (tTree[i].len < 100000){
                int up = tTree[id2].len;
                int l = tTree[id2].l;
                int r = tTree[id2].r;

```

```

                tTree[i].l = getL(l,r,up,tTree[id1].l);
                tTree[i].r = getR(l,r,up,tTree[id1].r-1);
            } else {
                tTree[i].l = tTree[i].r = sID-1;
            }
        }
    }
}
int bit[MXN];
int lb(int a){ return a & -a; }
void update(int st, int v){
    for (int i=st; i<sID; i+=lb(i))
        bit[i] += v;
}
int query(int st){
    int res = 0;
    for (int i=st; i>0; i-=lb(i))
        res += bit[i];
    return res;
}
void DFS(int u){
    update(rk[u],1);
    FOR(it,q[u]){
        int id = it->ti;
        if (tTree[id].len == 0 || tTree[id].len > 100000)
            ans[it->id] = 0;
        else
            ans[it->id] = query(tTree[id].r-1) - query(tTree[id].l-1);
    }
    FOR(it,E[u])
        DFS(*it);
    update(rk[u],-1);
}
void solve(){
    DFS(1);
    for (int i=0; i<nq; i++)
        printf("%d\n", ans[i]);
}
int main(){
    input();
    prvSolve();
    solve();

    return 0;
}

```