

# euclid

```
// ax+by=gcd
int gcd(int a,int b,int&x,int&y){
    x=1;y=0;
    int x1=0,y1=1,a1=a,b1=b;
    while(b1){
        int q=a1/b1;
        tie(x,x1)=make_tuple(x1,x-q*x1);
        tie(y,y1)=make_tuple(y1,y-q*y1);
        tie(a1,b1)=make_tuple(b1,a1-q*b1);
    }
    return a1;
}
```

# maxflow

```
struct MaxFlow{
    int n;
    vector<vector<int>>>adj;
    vector<vector<ll>>>cp;

    MaxFlow(int n):n(n){
        adj=vector<vector<int>>>(n);
        cp=vector(n,vector(n,0LL));
    }

    // connect a and b with capacity c
    void add(int a,int b,int c){
        if(cp[a][b]==0){
            adj[a].push_back(b);
            adj[b].push_back(a);
        }
        cp[a][b]+=c;
    }

    ll bfs(int s,int t,vector<int>&p){
        fill(p.begin(),p.end(),-1);
        p[s]=-2;
        queue<pair<int,int>>q;
        q.push({s,1e9});
        while(!q.empty()){
            int c=q.front().first;
            ll f=q.front().second;
            q.pop();
            for(int x:adj[c]){
                if(p[x]==-1&&cp[c][x]){
                    p[x]=c;
                    ll r=min(f,cp[c][x]);
                    if(x==t)
                        return r;
                    q.push({x,r});
                }
            }
        }
        return 0;
    }

    // call only once
    ll maxflow(int s,int t){
        ll f=0,r;
        vector<int>pr(n);
        while((r=bfs(s,t,pr))){
            f+=r;
            int cu=t;
            while(cu!=s){
                int p=pr[cu];
                cp[p][cu]-=r;
                cp[cu][p]+=r;
                cu=p;
            }
        }
        return f;
    }
};
```

# modulo\_int

```
const int MOD=1e9+7,PC=1e7;
ll M_inv[PC+1];
struct M{
    ll val=0;
    static void precomp(){M_inv[1]=1;for(ll i=2;i<=PC;++i){
        M_inv[i]=(MOD-MOD/i)*M_inv[MOD%i]%MOD;if(M_inv[i]<0)M_inv[i]+=MOD;}}
    static ll calc_inv(ll i){if(i<=PC)return M_inv[i];
        return (MOD-MOD/i)*calc_inv(MOD%i)%MOD;}
    M(ll x){val=(x%MOD+MOD)%MOD;}
    M()=default;
    template<class T>bool operator==(T b){return val==M(b).val;}
    template<class T>bool operator!=(T b){return val!=M(b).val;}
    template<class T>M operator+(T bt){M b(bt);M r(val);r.val+=b.val;if(r.val>=MOD)
        r.val-=MOD;return r;}
    template<class T>M operator-(T bt){M b(bt);M r(val);r.val+=MOD-b.val;if(r.val>=MOD)
        r.val-=MOD;return r;}
    template<class T>M operator*(T bt){M b(bt);M r(val);r.val*=b.val;r.val%=MOD;return r;}
    template<class T>M&operator+=(T bt){M b(bt);*this=*this+b;return*this;}
    template<class T>M&operator-=(T bt){M b(bt);*this=*this-b;return*this;}
    template<class T>M&operator*=(T bt){M b(bt);*this=*this*b;return*this;}
```

```

M pow(ll e){M r(1);M a(val);while(e){if(e%2)r=r*a;a=a*a;e/=2;}return r;}
template<class T>M operator/(T bt){ M b(bt); return M(val*calc_inv(b.val)); }
template<class T>M&operator/=(T bt){M b(bt);*this*=calc_inv(b.val);return*this;}
};
namespace std{template<>struct hash<M>{
    inline size_t operator()(const M&x)const{return x.val;}
};}
template<class T>bool operator<(T at,T bt){M b(bt);M a(at);return a.val<b.val;}
ostream&operator<<(ostream&s,M m){s<<m.val;return s;}
istream&operator>>(istream&s,M&m){s>>m.val;return s;}

```

## segtree

```

template<typename T>
struct SegTree{
    int n;
    vector<T>t;
    T (*m)(T,T);

    // n = size, d = default value, m = merge function
    SegTree(int n,T d,T(*m)(T,T)):n(n),m(m){
        t=vector<T>(2*n,d);
        for(int i=n-1;i>0;i--){
            t[i]=m(t[2*i],t[2*i+1]);
        }

        // point update
        void upd(int i,T x){
            i+=n;
            t[i]=x;
            while(i>1){
                i/=2;
                t[i]=m(t[2*i],t[2*i+1]);
            }
        }

        // range query
        T get(int l,int r){
            l+=n;
            r+=n;
            T rs=t[l];
            l++;
            while(l<r){
                if(l%2){
                    rs=m(rs,t[l]);
                    l++;
                }
                if(r%2){
                    r--;
                    rs=m(rs,t[r]);
                }
                l/=2;
                r/=2;
            }
            return rs;
        }
    };
};

```

## suffix\_array

```

vector<int> sort_cyclic_shifts(string const& s) {
    int n = s.size();
    const int alphabet = 256;
    vector<int> p(n), c(n), cnt(max(alphabet, n), 0);
    for (int i = 0; i < n; i++)
        cnt[s[i]]++;
    for (int i = 1; i < alphabet; i++)
        cnt[i] += cnt[i-1];
    for (int i = 0; i < n; i++)
        p[--cnt[s[i]]] = i;
    c[p[0]] = 0;
    int classes = 1;
    for (int i = 1; i < n; i++) {
        if (s[p[i]] != s[p[i-1]])
            classes++;
        c[p[i]] = classes - 1;
    }
    vector<int> pn(n), cn(n);
    for (int h = 0; (1 << h) < n; ++h) {
        for (int i = 0; i < n; i++) {
            pn[i] = p[i] - (1 << h);
            if (pn[i] < 0)
                pn[i] += n;
        }
        fill(cnt.begin(), cnt.begin() + classes, 0);
        for (int i = 0; i < n; i++)
            cnt[c[pn[i]]]++;
        for (int i = 1; i < classes; i++)
            cnt[i] += cnt[i-1];
        for (int i = n-1; i >= 0; i--)
            p[--cnt[c[pn[i]]]] = pn[i];
        cn[p[0]] = 0;
        classes = 1;
        for (int i = 1; i < n; i++) {
            pair<int, int> cur = {c[p[i]], c[(p[i] + (1 << h)) % n]};
            pair<int, int> prev = {c[p[i-1]], c[(p[i-1] + (1 << h)) % n]};
            if (cur != prev)
                ++classes;
            cn[p[i]] = classes - 1;
        }
    }
}

```

```

    c.swap(cn);
}
return p;
}

vector<int> suffix_array_construction(string s) {
    s += "$";
    vector<int> sorted_shifts = sort_cyclic_shifts(s);
    sorted_shifts.erase(sorted_shifts.begin());
    return sorted_shifts;
}

int compare(int i, int j, int l, int k) {
    pair<int, int> a = {c[k][i], c[k][(i+l-(1 << k))%n]};
    pair<int, int> b = {c[k][j], c[k][(j+l-(1 << k))%n]};
    return a == b ? 0 : a < b ? -1 : 1;
}

int lcp(int i, int j) {
    int ans = 0;
    for (int k = log_n; k >= 0; k--) {
        if (c[k][i % n] == c[k][j % n]) {
            ans += 1 << k;
            i += 1 << k;
            j += 1 << k;
        }
    }
    return ans;
}

vector<int> lcp_construction(string const& s, vector<int> const& p) {
    int n = s.size();
    vector<int> rank(n, 0);
    for (int i = 0; i < n; i++)
        rank[p[i]] = i;

    int k = 0;
    vector<int> lcp(n-1, 0);
    for (int i = 0; i < n; i++) {
        if (rank[i] == n - 1) {
            k = 0;
            continue;
        }
        int j = p[rank[i] + 1];
        while (i + k < n && j + k < n && s[i+k] == s[j+k])
            k++;
        lcp[rank[i]] = k;
        if (k)
            k--;
    }
    return lcp;
}

```

## z\_algorithm

```

// z[i] pove, da se z[i] znakovl zacensi z i-tim ujemajo s prvimi z[i] znaki stringa s.
vector<int> z_function(string s) {
    int n = s.size();
    vector<int> z(n);
    int l = 0, r = 0;
    for(int i = 1; i < n; i++) {
        if(i < r) {
            z[i] = min(r - i, z[i - l]);
        }
        while(i + z[i] < n && s[z[i]] == s[i + z[i]]) {
            z[i]++;
        }
        if(i + z[i] > r) {
            l = i;
            r = i + z[i];
        }
    }
    return z;
}

```

## tarjan

```

int N, M, timer, tin[maxN], low[maxN];
bool vis[maxN];
vector<int> G[maxN];
vector<pii> bridges;

void dfs(int u = 1, int p = 0){
    vis[u] = true;
    tin[u] = low[u] = ++timer;
    for(int v : G[u]){
        if(v != p){
            if(vis[v]) low[u] = min(low[u], tin[v]);
            else {
                dfs(v, u);
                low[u] = min(low[u], low[v]);
                if(low[v] > tin[u])
                    bridges.push_back({u, v});
            }
        }
    }
}

```

# tree\_hash

```
const ll MOD=100000004987;

ll primes[]={
    1000000007,
    1000000207,
    1000000409,
    1000000531,
    1000000829,
    1000001021,
    1000001269,
    1000001447,
};

int n;
vector<int> nodes[100000];
int sub_size[100000];

void init_tree(int node,int par){
    sub_size[node]=1;
    for(int ne:nodes[node]){
        if(ne!=par){
            init_tree(ne,node);
            sub_size[node]+=sub_size[ne];
        }
    }
}

ll hash_tree(int node,int par,int depth){
    ll prime=primes[(depth+sub_size[node])%8];

    if(nodes[node].size()==1&&node!=par){
        return prime;
    }

    vector<ll> hashes;
    for(int ne:nodes[node]){
        if(ne==par)
            continue;
        hashes.push_back(hash_tree(ne,node,depth+1));
    }
    sort(hashes.begin(),hashes.end());
    ll res=0;
    ll cp=prime;
    for(ll i:hashes){
        res+=cp*i;
        res%=MOD;
        cp*=prime;
        cp%=MOD;
    }

    /*if(par==0||node==0)
        cout<<res<<"\n";*/

    return res;
}

pair<int,int> get_centroid(int node,int par){
    int biggest=-1;
    for(int ne:nodes[node]){
        if(ne==par)
            continue;
        if(biggest==-1||sub_size[ne]>sub_size[biggest])
            biggest=ne;
    }

    if(sub_size[biggest]<=sub_size[0]/2)
        return {node,biggest};
    return get_centroid(biggest,node);
}

// USAGE
cin>>n;
for(int i=0;i<n;i++)
    nodes[i].clear();
for(int i=0;i<n-1;i++){
    int a,b;
    cin>>a>>b;
    a--;b--;
    nodes[a].push_back(b);
    nodes[b].push_back(a);
}
init_tree(0,0);
pair<int,int> root=get_centroid(0,0);
init_tree(root.first,root.first);
ll hash11=hash_tree(root.first,root.first,0);
init_tree(root.second,root.second);
ll hash12=hash_tree(root.second,root.second,0);

for(int i=0;i<n;i++)
    nodes[i].clear();
for(int i=0;i<n-1;i++){
    int a,b;
    cin>>a>>b;
    a--;b--;
    nodes[a].push_back(b);
    nodes[b].push_back(a);
}
init_tree(0,0);
root=get_centroid(0,0);
init_tree(root.first,root.first);
ll hash21=hash_tree(root.first,root.first,0);
init_tree(root.second,root.second);
ll hash22=hash_tree(root.second,root.second,0);

cout<<((hash11==hash21||hash12==hash22||hash11==hash22||hash12==hash21)?"YES\n":"NO\n");
```

## hash\_string

```
const int HMOD=1e9+7;
const int HX=31;

class FastString{
    string str;
    vector<ll>hashes;
    vector<ll>pows;
    int len;
public:
    FastString(string str):str(str){
        len=(int)str.size();
        hashes.resize(len+1);
        pows.resize(len+1);
        pows[0]=1;
        for(int i=1;i<=len;i++)
            pows[i]=(pows[i-1]*HX)%HMOD;

        hashes[0]=0;
        for(int i=1;i<=len;i++)
            hashes[i]=(hashes[i-1]+pows[i-1]*(str[i-1]-'a'+1))%HMOD;
    }

    ll get(int l,int r){
        ll hsh=hashes[r]+HMOD-hashess[l];
        hsh%=HMOD;
        hsh*=pows[len-l];
        hsh%=HMOD;
        return hsh;
    }
};
```

## convex\_hull

```
struct pt {
    double x, y;
    bool operator == (pt const& t) const {
        return x == t.x && y == t.y;
    }
};

int orientation(pt a, pt b, pt c) {
    double v = a.x*(b.y-c.y)+b.x*(c.y-a.y)+c.x*(a.y-b.y);
    if (v < 0) return -1; // clockwise
    if (v > 0) return +1; // counter-clockwise
    return 0;
}

bool cw(pt a, pt b, pt c, bool include_collinear) {
    int o = orientation(a, b, c);
    return o < 0 || (include_collinear && o == 0);
}

bool collinear(pt a, pt b, pt c) { return orientation(a, b, c) == 0; }

void convex_hull(vector<pt>& a, bool include_collinear = false) {
    pt p0 = *min_element(a.begin(), a.end(), [](pt a, pt b) {
        return make_pair(a.y, a.x) < make_pair(b.y, b.x);
    });
    sort(a.begin(), a.end(), [&p0](const pt& a, const pt& b) {
        int o = orientation(p0, a, b);
        if (o == 0)
            return (p0.x-a.x)*(p0.x-a.x) + (p0.y-a.y)*(p0.y-a.y)
                < (p0.x-b.x)*(p0.x-b.x) + (p0.y-b.y)*(p0.y-b.y);
        return o < 0;
    });
    if (include_collinear) {
        int i = (int)a.size()-1;
        while (i >= 0 && collinear(p0, a[i], a.back())) i--;
        reverse(a.begin()+i+1, a.end());
    }

    vector<pt> st;
    for (int i = 0; i < (int)a.size(); i++) {
        while (st.size() > 1 && !cw(st[st.size()-2], st.back(), a[i], include_collinear))
            st.pop_back();
        st.push_back(a[i]);
    }

    if (include_collinear == false && st.size() == 2 && st[0] == st[1])
        st.pop_back();

    a = st;
}
```