

# C++ Header Files

## Contents

Header.hpp	1
ST 表.hpp	2
custom_hash.hpp	2
dq.hpp	3
fraction.hpp	3
modint.hpp	4
pbds.hpp	5
poly.hpp	6
trie.hpp	14
vector.hpp	14
哈希.hpp	15
图论.hpp	18
堆.hpp	23
字符串.hpp	24
并查集.hpp	26
数论.hpp	28
树.hpp	34
树状数组.hpp	38
矩阵.hpp	40
离散化.hpp	41
线性基.hpp	42
线段树.hpp	44
网络流.hpp	47
计算几何.hpp	50

## Header.hpp

```
#pragma GCC optimize("Ofast,no-stack-protector,unroll-loops")
#define ALL(v) v.begin(),v.end()
#define For(i,_) for(int i=0,i##end=_;i<i##end;++i) // [0,_)
#define FOR(i,_,__) for(int i=_,i##end=__;i<i##end;++i) // [_,__)
#define Rep(i,_) for(int i=(_-1);i>=0;--i) // [0,_)
#define REP(i,_,__) for(int i=(__)-1,i##end=_;i>=i##end;--i) // [_,__)
typedef long long ll;
typedef unsigned long long ull;
#define V vector
#define pb push_back
#define pf push_front
#define qb pop_back
#define qf pop_front
#define eb emplace_back
```

```

typedef pair<int,int> pii;
typedef pair<ll,int> pli;
#define fi first
#define se second
const int dir[4][2]={-1,0},{0,1},{1,0},{0,-1},inf=0x3f3f3f3f,mod=1e9+7;
const ll infl=0x3f3f3f3f3f3f3f3fll;
template<class T>inline bool ckmin(T &x,const T &y){return x>y?x=y,1:0;}
template<class T>inline bool ckmax(T &x,const T &y){return x<y?x=y,1:0;}
int init=[](){return cin.tie(nullptr)->sync_with_stdio(false),0;}();

```

## ST 表.hpp

```

template<class T,T(*merge)(T,T)>
struct ST{
    V<V<T>>st;
    inline ST(){}
    inline ST(const V<T> &a){
        int n=a.size(),B=__lg(n);
        V<V<T>>(B+1).swap(st);
        st[0]=a;
        FOR(i,1,B+1){
            st[i].resize(n-(1<<i)+1);
            For(j,n-(1<<i)+1)st[i][j]=merge(st[i-1][j],st[i-1][j+(1<<i-1)]);
        }
    }
    inline ST(const V<T> &a,const V<int> &pos){
        assert(a.size()==pos.size());
        int n=a.size(),B=__lg(n);
        V<V<T>>(B+1).swap(st);
        For(i,B+1){
            st[i].resize(n-(1<<i)+1);
            if(i)For(j,n-(1<<i)+1)st[i][j]=merge(st[i-1][j],st[i-1][j+(1<<i-1)]);
            else For(i,n)st[0][pos[i]]=a[i];
        }
    }
    inline T query(int l,int r){
        int n=st[0].size();
        assert(0<=l),assert(l<=r),assert(r<n);
        int k=__lg(r-l+1);
        return merge(st[k][l],st[k][r-(1<<k)+1]);
    }
};

```

## custom\_hash.hpp

```

struct custom_hash {
    static uint64_t splitmix64(uint64_t x){
        x+=0x9e3779b97f4a7c15;
        x=(x^(x>>30))*0xbf58476d1ce4e5b9;
        x=(x^(x>>27))*0x94d049bb133111eb;
        return x^(x>>31);
    }
    size_t operator()(uint64_t x)const{

```

```

        static const uint64_t
        ↪ FIXED_RANDOM=chrono::steady_clock::now().time_since_epoch().count();
        return splitmix64(x+FIXED_RANDOM);
    }
};

```

## dq.hpp

```

template<class T>
struct dq{
    int hd;
    V<T>q;
    inline dq(){hd=0;}
    inline T front(int k=0){assert(hd+k<q.size());return q[hd+k];}
    inline T back(int k=0){assert(hd+k<q.size());return q[q.size()-1-k];}
    inline int size(){return q.size()-hd;}
    inline void clear(){hd=0,V<T>().swap(q);}
    inline void push(const T &v){q.pb(v);}
    inline void pop_back(){q.qb();}
    inline void pop_front(){assert(hd<q.size());++hd;}
};

```

## fraction.hpp

```

struct fraction{
    ll p,q;
    inline void simplify(){ll g=gcd(p<0?-p:p,q);p/=g;q/=g;}
    inline explicit fraction(ll _p=0):p(_p),q(1){}
    inline fraction(ll _p,ll
        ↪ _q):p(_p),q(_q){assert(q);if(q<0)p=-p,q=-q;simplify();}
    inline explicit fraction(const string&s){size_t pos=s.find('.');q=1;if(pos==
        ↪ string::npos)p=stoll(s);else{if(pos+1<s.size()){for(int
        ↪ i=0;i<s.size()-1-pos;i++)q*=10;p=(pos?stoll(s.substr(0,pos))*q:0)+stoll(s
        ↪ .substr(pos+1));}else
        ↪ p=stoll(s.substr(0,pos));simplify();}}
    inline explicit fraction(const V<char>&s):fraction(string(s.begin(),s.end())){}
    inline fraction& operator=(const fraction&r){p=r.p;q=r.q;return*this;}
    inline fraction& operator=(ll r){p=r;q=1;return*this;}
    inline fraction operator+(const fraction&r)const{if(q==r.q)return{p+r.p,q};ll
        ↪ g=gcd(q,r.q),m=q/g;return{p*(r.q/g)+r.p*m,m*r.q};}
    inline fraction operator+(ll r)const{return{p+r*q,q};}
    inline fraction add(const fraction&r)const{return{p*r.q+r.p*q,q*r.q};}
    inline fraction operator-(const fraction&r)const{if(q==r.q)return{p-r.p,q};ll
        ↪ g=gcd(q,r.q),m=q/g;return{p*(r.q/g)-r.p*m,m*r.q};}
    inline fraction operator-(ll r)const{return{p-r*q,q};}
    inline fraction sub(const fraction&r)const{return{p*r.q-r.p*q,q*r.q};}
    inline fraction operator*(const fraction&r)const{fraction t;ll g1=gcd(p,r.q),
        ↪ g2=gcd(r.p,q);t.p=(p/g1)*(r.p/g2);t.q=(q/g2)*(r.q/g1);return
        ↪ t;}
    inline fraction operator*(ll r)const{fraction t=*this;ll
        ↪ g=gcd(r,q);t.p*=r/g;t.q/=g;return t;}
    inline fraction mul(const fraction&r)const{return{p*r.p,q*r.q};}
};

```

```

inline fraction operator/(const fraction&r) const {assert(r.p); fraction t; ll g1
    ↪ =gcd(p, r.p), g2=gcd(r.q, q); t.p=(p/g1)*(r.q/g2); t.q=(q/g2)*(r.p/g1); return
    ↪ t;}
inline fraction operator/(ll r) const {assert(r); fraction t=*this; ll
    ↪ g=gcd(p, r); t.p/=g; t.q*=r/g; return t;}
inline fraction div(const fraction&r) const {assert(r.p); return {p*r.q, q*r.p};}
inline bool operator==(const fraction&r) const {return p==r.p&&q==r.q;}
inline bool operator==(ll r) const {return p==r&&q==1;}
inline bool eq(const fraction&r) const {return p==r.p&&q==r.q;}
inline bool operator<(const fraction&r) const {return p*r.q<r.p*q;}
inline bool operator<(ll r) const {ll g=gcd(p, r); return p/g<q*(r/g);}
inline bool lt(const fraction&r) const {return p*r.q<r.p*q;}
inline bool operator>(const fraction&r) const {return p*r.q>r.p*q;}
inline bool operator>(ll r) const {ll g=gcd(p, r); return p/g>q*(r/g);}
inline bool gt(const fraction&r) const {return p*r.q>r.p*q;}
inline bool operator<=(const fraction&r) const {return p*r.q<=r.p*q;}
inline bool operator<=(ll r) const {ll g=gcd(p, r); return p/g<=q*(r/g);}
inline bool le(const fraction&r) const {return p*r.q<=r.p*q;}
inline bool operator>=(const fraction&r) const {return p*r.q>=r.p*q;}
inline bool operator>=(ll r) const {ll g=gcd(p, r); return p/g>=q*(r/g);}
inline bool ge(const fraction&r) const {return p*r.q>=r.p*q;}
inline string to_string() const {return ::to_string(p)+'/'+::to_string(q);}
};

```

## modint.hpp

```

template<int p>
struct modint{
    int val;
    inline modint(int v=0):val(v){}
    inline modint& operator=(int v){val=v; return *this;}
    inline modint& operator+=(const
    ↪ modint&k){val=val+k.val>=p?val+k.val-p:val+k.val; return *this;}
    inline modint& operator-=(const
    ↪ modint&k){val=val-k.val<0?val-k.val+p:val-k.val; return *this;}
    inline modint& operator*=(const modint&k){val=int(1ll*val*k.val%p); return
    ↪ *this;}
    inline modint& operator^=(int k){modint
    ↪ r(1), b=*this; for(; k>=1, b*=b) if(k&1) r*=b; val=r.val; return *this;}
    inline modint& operator/=(modint k){return *this*= (k^=p-2);}
    inline modint& operator+=(int k){val=val+k>=p?val+k-p:val+k; return *this;}
    inline modint& operator-=(int k){val=val<k?val-k+p:val-k; return *this;}
    inline modint& operator*=(int k){val=int(1ll*val*k%p); return *this;}
    inline modint& operator/=(int k){return *this*= ((modint(k))^=p-2);}
    template<class T> friend modint operator+(modint a, T b){return a+=b;}
    template<class T> friend modint operator-(modint a, T b){return a-=b;}
    template<class T> friend modint operator*(modint a, T b){return a*=b;}
    template<class T> friend modint operator/(modint a, T b){return a/=b;}
    friend modint operator^(modint a, int b){return a^=b;}
    friend bool operator==(modint a, int b){return a.val==b;}
    friend bool operator!=(modint a, int b){return a.val!=b;}
    inline bool operator!() const {return !val;}
    inline modint operator-() const {return val?modint(p-val):modint(0);}
    inline modint operator++(int){modint t=*this; *this+=1; return t;}
}

```

```

    inline modint& operator++(){return *this+=1;}
    inline modint operator--(int){modint t=*this;*this-=1;return t;}
    inline modint& operator--(){return *this-=1;}
};
using mi=modint<mod>;

```

## pbds.hpp

```

#include <ext/pb_ds/tree_policy.hpp>
#include <ext/pb_ds/assoc_container.hpp>
using namespace __gnu_pbds;

template<class T>
struct rbt{
    typedef pair<T,int> pti;
    int cnt;
    typedef tree<pti,null_type,less<pti>,rb_tree_tag,
        ↪ tree_order_statistics_node_update>
        ↪ rbt_t;
    rbt_t t;
    inline rbt(){cnt=0;}
    inline void clear(){cnt=0,rbt_t().swap(t);}
    inline typename rbt_t::iterator begin(){return t.begin();}
    inline typename rbt_t::iterator end(){return t.end();}
    inline void insert(const T &x){t.insert({x,cnt++});}
    inline typename rbt_t::iterator find(const T &x){return t.lower_bound({x,0});}
    inline void erase(const T &x){t.erase(find(x));}
    inline T pre(const T &x){
        auto it=find(x);
        assert(it!=begin());
        return prev(it)->fi;
    }
    inline T nxt(const T &x){
        auto it=find(x+1);
        assert(it!=end());
        return it->fi;
    }
    // all 0-indexed
    inline int rk(const T &x){return t.order_of_key({x,0});}
    inline T at(unsigned x){return t.find_by_order(x)->fi;}
};

#include <ext/pb_ds/priority_queue.hpp>
inline V<ll> dijkstra(int n,int s,const V<V<pii>> &to){
    assert(0<=n),assert(0<=s),assert(s<n),assert(to.size()<=n);
    for(const V<pii> &i:to)
        for(const pii &j:i)
            assert(0<=min(j.fi,j.se)),assert(j.fi<n);
    V<ll>dis(n,infl);
    dis[s]=0;
    __gnu_pbds::priority_queue<pli,greater<pli>,pairing_heap_tag>q;
    V<decltype(q)::point_iterator>it(n);
    it[s]=q.push({0,s});
    while(q.size()){

```

```

    int p=q.top().se;q.pop();
    for(const pii &i:to[p])
        if(ckmin(dis[i.fi],dis[p]+i.se)){
            if(it[i.fi]!=NULL)q.modify(it[i.fi],{dis[i.fi],i.fi});
            else it[i.fi]=q.push({dis[i.fi],i.fi});
        }
    }
    for(ll &i:dis)if(i==infl)i=-1;
    return dis;
}

```

## poly.hpp

```

inline V<mi> poly_conv_add(const V<mi> &a,const V<mi> &b,int g){ //
    ⇨ c[k]=Σ(a[i]*b[j]) for i+j=k verified with lg3803
    assert(_a.size()&&_b.size());
    if(max(_a.size(),_b.size())<17){
        V<mi>c(_a.size()+_b.size()-1);
        For(i,_a.size())For(j,_b.size())c[i+j]+=_a[i]*_b[j];
        return c;
    }
    int lg=0,n=1;
    while(n<_a.size()+_b.size()-1)++lg,n<=1;
    V<mi>a=_a,b=_b;
    a.resize(n),b.resize(n);
    static V<V<int>>>btf;
    while(btf.size()<=lg){
        int n=1<<btf.size();
        btf.pb({});
        V<int>&bf=btf.back();
        bf.resize(n);
        For(i,n)bf[i]=(bf[i>>1]>>1)|((i&1)?n>>1:0);
    }
    const V<int>&bf=btf[lg];
    auto NTT=[&](V<mi> &f,mi coef){
        For(i,n)if(i<bf[i])swap(f[i],f[bf[i]]);
        for(int k=1,l=2;k<n;k<=1,l<=1){
            mi wn=coef^((mod-1)/l);
            for(int i=0;i<n;i+=l){
                mi w=1;
                For(j,k){
                    mi x=f[i|j],y=w*f[i|j|k];
                    f[i|j]=x+y,f[i|j|k]=x-y;
                    w*=wn;
                }
            }
        }
    };
    NTT(a,g),NTT(b,g);
    For(i,n)a[i]*=b[i];
    NTT(a,mi(1)/g);
    a.resize(_a.size()+_b.size()-1);
    mi invn=mi(1)/n;
    for(mi &i:a)i*=invn;

```

```

    return a;
}

inline V<mi> poly_conv_sub(const V<mi> &_a, const V<mi> &_b, int g){ //
    ↪ c[k]=Σ(a[i]*b[j]) for i-j=k verified with gym105386H
    assert(_a.size()&&_b.size());
    V<mi>b=_b;
    reverse(ALL(b));
    b=poly_conv_add(_a,b,g);
    // (-b.size(),a.size()) -> [0,a.size())
    b.erase(b.begin(),b.begin()+_b.size()-1);
    return b;
}

inline int find_g(int m){
    auto phi=[&](int k){
        int ret=k;
        for(int i=2;i*i<=k;++i)if(k%i==0){ret-=ret/i;do k/=i;while(k%i==0);}
        if(k>1)ret-=ret/k;
        return ret;
    };
    int p=phi(m);
    V<int>fac;
    {
        int j=p;
        for(int i=2;i*i<=j;++i)if(j%i==0){fac.pb(p/i);do j/=i;while(j%i==0);}
        if(j>1)fac.pb(p/j);
    }
    auto check_g=[&](int g){
        auto qpow=[&](int x,int y){
            int z=1;
            for(;y;x=1ll*x*x%m,y>=>1)if(y&1)z=1ll*z*x%m;
            return z;
        };
        if(qpow(g,p)!=1)return false;
        for(int i:fac)if(qpow(g,i)==1)return false;
        return true;
    };
    FOR(i,1,m)if(check_g(i))return i;
    return -1;
}

inline V<mi> poly_conv_mul(const V<mi> &_a, const V<mi> &_b, int g, int p, int pg=-1){
    ↪ // c[k]=Σ(a[i]*b[j]) for i*j%p=k verified by qoj9247
    assert(_a.size()&&_b.size());
    if(!~pg)pg=find_g(p);
    assert(~pg);
    V<int>exp(p-1),lg(p);
    lg[0]=-1;
    for(int i=1,j=0;j<p-1;i=1ll*i*pg%p,++j)exp[j]=i,lg[i]=j;
    V<mi>a(p-1),b(p-1);
    FOR(i,1,_a.size())a[lg[i]]=_a[i];
    FOR(i,1,_b.size())b[lg[i]]=_b[i];
    V<mi>c=poly_conv_add(a,b,g);
    FOR(i,p-1,c.size())c[i-(p-1)]+=c[i];
}

```

```

V<mi>d(p);
d[0]=_a[0]*reduce(ALL(_b))+_b[0]*reduce(ALL(_a))-_a[0]*_b[0];
For(i,p-1)d[exp[i]]=c[i];
return d;
}

inline V<mi> poly_conv_div(const V<mi> &a,const V<mi> &b,int g,int p,int pg=-1){
↪ // c[k]=Σ(a[i]*b[j]) for i/j%p=k not verified
assert(_a.size()&&_b.size()),assert(!_b[0].val);
V<int>inv(p);
inv[1]=1;
FOR(i,1,p)inv[i]=1ll*(p-p/i)*inv[p%i]%mod;
V<mi>b(p);
FOR(i,1,_b.size())b[inv[i]]=_b[i];
return poly_conv_mul(_a,b,g,p,pg);
}

inline V<mi> poly_conv_and(const V<mi> &a,const V<mi> &b){ // c[k]=Σ(a[i]*b[j])
↪ for i&j=k verified with lg4717
assert(_a.size()&&_b.size());
int n=1;
while(n<max(_a.size(),_b.size()))n<=<=1;
V<mi>a=_a,b=_b;
a.resize(n),b.resize(n);
auto FWT=[&](V<mi> &f,int coef){
    for(int k=1,l=2;k<n;k<=<=1,l<=<=1)for(int
        ↪ i=0;i<n;i+=l)For(j,k)f[i|j]+=f[i|j|k]*coef;
};
FWT(a,1),FWT(b,1);
For(i,n)a[i]*=b[i];
FWT(a,mod-1);
return a;
}

inline V<mi> poly_conv_or(const V<mi> &a,const V<mi> &b){ // c[k]=Σ(a[i]*b[j])
↪ for i|j=k verified with lg4717
assert(_a.size()&&_b.size());
int n=1;
while(n<max(_a.size(),_b.size()))n<=<=1;
V<mi>a=_a,b=_b;
a.resize(n),b.resize(n);
auto FWT=[&](V<mi> &f,int coef){
    for(int k=1,l=2;k<n;k<=<=1,l<=<=1)for(int
        ↪ i=0;i<n;i+=l)For(j,k)f[i|j|k]+=f[i|j]*coef;
};
FWT(a,1),FWT(b,1);
For(i,n)a[i]*=b[i];
FWT(a,mod-1);
return a;
}

inline V<mi> poly_conv_xor(const V<mi> &a,const V<mi> &b){ // c[k]=Σ(a[i]*b[j])
↪ for i^j=k verified with lg4717
assert(_a.size()&&_b.size());

```



```

    int n=1;
    while(n<max(_a.size(),_b.size()))n<=1;
    V<mi>a=_a,b=_b;
    a.resize(n),b.resize(n);
    auto FWT=[&](V<mi> &f,int coef){
        for(int k=1,l=2;k<n;k<=1,l<=1)for(int i=0;i<n;i+=l)for(j,k){
            mi x=f[i|j],y=f[i|j|k];
            f[i|j]=(x+y)*coef,f[i|j|k]=(x-y)*coef;
        }
    };
    FWT(a,1),FWT(b,1);
    for(i,n)a[i]*=b[i];
    FWT(a,mod+1>>1);
    return a;
}

inline V<mi> poly_conv_gcd(const V<mi> &a,const V<mi> &b){ // c[k]=∑(a[i]*b[j])
    ↪ for gcd(i,j)=k verified with lc418t4
    assert(_a.size()&&_b.size());
    int n=max(_a.size(),_b.size());
    V<mi>a=_a,b=_b;
    a.resize(n),b.resize(n);
    V<int>pri;
    V<bool>vis(n);
    FOR(i,2,n)if(!vis[i]){
        pri.pb(i);
        for(int k=(n-1)/i,j=k*i;k;j-=i,--k)a[k]+=a[j],b[k]+=b[j],vis[j]=true;
    }
    FOR(i,1,n)a[i]*=b[i];
    for(int i:pri)for(int j=i,k=1;j<n;j+=i,++k)a[k]-=a[j];
    a[0]=_a[0]*_b[0];
    FOR(i,1,n)a[i]+=_a[0]*_b[i]+_b[0]*_a[i];
    return a;
}

inline V<mi> poly_conv_lcm(const V<mi> &a,const V<mi> &b){ // c[k]=∑(a[i]*b[j])
    ↪ for lcm(i,j)=k not verified
    assert(_a.size()&&_b.size());
    int n=max(_a.size(),_b.size());
    V<mi>a=_a,b=_b;
    a.resize(n),b.resize(n);
    V<int>pri;
    V<bool>vis(n);
    FOR(i,2,n)if(!vis[i]){
        pri.pb(i);
        for(int j=i,k=1;j<n;j+=i,++k)a[j]+=a[k],b[j]+=b[k],vis[j]=true;
    }
    FOR(i,1,n)a[i]*=b[i];
    for(int i:pri)for(int k=(n-1)/i,j=k*i;k;j-=i,--k)a[j]-=a[k];
    a[0]=_a[0]*_b[0];
    FOR(i,1,n)a[i]+=_a[0]*_b[i]+_b[0]*_a[i];
    return a;
}

```

```

}

inline V<mi> poly_inv(const V<mi> &a,int g){ // b=1/a verified with lg4238
    assert(a.size()),assert(a[0].val);
    V<mi>b{1/a[0]};
    mi invg=mi(1)/g,invm=1;
    int m=1;
    while(b.size()<a.size()){
        int n=min(a.size(),b.size()<<1);
        while(m<=n-1<<1)invm*=mod+1>>1,m<=<=1;
        V<mi>c(a.begin(),a.begin()+n);
        b.resize(m),c.resize(m);
        V<int>bf(m);
        For(i,m)bf[i]=(bf[i>>1]>>1)|((i&1)?m>>1:0);
        auto NTT=[&](V<mi> &f,mi coef){
            For(i,m)if(i<bf[i])swap(f[i],f[bf[i]]);
            for(int k=1,l=2;k<m;k<=<=1,l<=<=1){
                mi wn=coef^((mod-1)/l);
                for(int i=0;i<m;i+=l){
                    mi w=1;
                    For(j,k){
                        mi x=f[i|j],y=w*f[i|j|k];
                        f[i|j]=x+y,f[i|j|k]=x-y;
                        w*=wn;
                    }
                }
            }
        };
        NTT(b,g),NTT(c,g);
        For(i,m)b[i]*=2-b[i]*c[i];
        NTT(b,inv);
        b.resize(n);
        for(mi &i:b)i*=invm;
    }
    return b;
}

inline V<mi> poly_diff(const V<mi> &a){ // b=a'
    int n=a.size();
    assert(n);
    if(n==1)return {0};
    V<mi>b(n-1);
    For(i,n-1)b[i]=a[i+1]*(i+1);
    return b;
}

inline V<mi> poly_intg(const V<mi> &a){ // b=∫a
    int n=a.size();
    assert(n);
    V<mi>b(n+1),inv(n+1);
    b[1]=a[0],inv[1]=1;
    FOR(i,2,n)b[i]=a[i-1]*(inv[i]=(mod-mod/i)*inv[mod%i]);
    return b;
}

```

```

inline V<mi> poly_ln(const V<mi> &a,int g){ // b=ln(a) verified with lg4725
    int n=a.size();
    assert(n),assert(a[0].val==1);
    V<mi>b=poly_conv_add(poly_diff(a),poly_inv(a,g),g);
    b.resize(n);
    return poly_intg(b);
}

inline V<mi> poly_exp(const V<mi> &a,int g){ // b=exp(a) verified with lg4726
    int n=a.size();
    assert(n);
    V<mi>b{1};
    if(a[0].val){
        mi e=0,ifac=mod-1;
        Rep(i,mod)e+=ifac,ifac*=i;
        b[0]=e^a[0].val; // check that a[0] isnt modulo
    }
    while(b.size()<a.size()){
        int m=min(b.size()<<1,a.size());
        b.resize(m);
        V<mi>c=poly_ln(b,g);
        For(i,m)c[i]=a[i]-c[i];
        ++c[0];
        b=poly_conv_add(b,c,g);
        b.resize(m);
    }
    return b;
}

inline V<mi> poly_series(const V<mi> &a,mi b0,int g){ // b[i]=Σ(b[j]*a[i-j]) for
↪ j>0 verified with lg4721
    assert(a.size());
    V<mi>b=a;
    b[0]=1;
    FOR(i,1,b.size())b[i]=-b[i];
    b=poly_inv(b,g);
    if(b0.val!=1)for(mi &i:b)i*=b0;
    return b;
}

inline V<mi> poly_pow(const V<mi> &a,mi b,int g){ // c=a^(b%mod) verified with
↪ lg5245
    int n=_a.size();
    assert(n);
    V<mi>a(n);
    if(!b){
        a[0]=1;
        return a;
    }
    int i=0;
    while(i<n&&!_a[i])++i;
    if(i==n)return a;
    ll z=1ll*b.val*i;

```

```

    if(z>=n) return a;
    assert(_a[i].val==1);
    a=poly_ln(V<mi>(_a.begin()+i,_a.end()),g);
    for(mi &j:a) j*=b;
    a=poly_exp(a,g);
    V<mi>ret(z);
    ret.insert(ret.end(),a.begin(),a.begin()+n-z);
    return ret;
}

inline V<mi> poly_pow(const V<mi> &a,ll b,int g){ // c=a^b verified with Library
    ⇨ Checker
    int n=_a.size();
    assert(n);
    V<mi>a(n);
    if(!b){
        a[0]=1;
        return a;
    }
    int i=0;
    while(i<n&&!_a[i])++i;
    if(i==n||__int128(b)*i>=n) return a;
    a=V<mi>(_a.begin()+i,_a.end());
    mi coef=a[0],inv=1/coef;
    for(mi &j:a) j*=inv;
    a=poly_ln(a,g);
    mi _b=b%mod;
    for(mi &j:a) j*=_b;
    a=poly_exp(a,g);
    coef^=b%(mod-1);
    for(mi &j:a) j*=coef;
    ll z=b*i;
    V<mi>ret(z);
    ret.insert(ret.end(),a.begin(),a.begin()+n-z);
    return ret;
}

inline V<mi> poly_multi_pt(const V<mi> &a,const V<mi> &b,int g){ // c[i]=a(b[i])
    ⇨ verified with lg5050
    assert(_a.size());
    if(b.empty()) return {};
    int n=max(_a.size(),b.size());
    V<V<mi>>t(n<<2);
    auto build=[&](auto &&self,int p,int l,int r)->void{
        if(l==r){
            t[p]={1,l<b.size()?b[r]:0};
            return;
        }
        int mid=l+r>>1;
        self(self,p<<1,l,mid);
        self(self,p<<1|1,mid+1,r);
        t[p]=poly_conv_add(t[p<<1],t[p<<1|1],g);
    };
    build(build,1,0,n-1);

```

```

    auto poly_conv_sub=[&](const V<mi> &a,const V<mi> &b,int g){
        assert(_b.size()),assert(_a.size()>=_b.size());
        V<mi>b=_b;
        reverse(ALL(b));
        b=poly_conv_add(_a,b,g);
        return V<mi>(b.begin()+_b.size()-1,b.end());
    };
    V<mi>ret(b.size());
    auto push_down=[&](auto &&self,int p,int l,int r,V<mi> c)->void{
        if(l>=b.size())return;
        if(l==r){
            ret[l]=c[0];
            return;
        }
        c.resize(r-l+1);
        int mid=l+r>>1;
        self(self,p<<1,l,mid,poly_conv_sub(c,t[p<<1|1],g));
        self(self,p<<1|1,mid+1,r,poly_conv_sub(c,t[p<<1],g));
    };
    V<mi>a=_a;
    a.resize(n+1);
    push_down(push_down,1,0,n-1,poly_conv_sub(a,poly_inv(t[1],g),g));
    return ret;
}

inline V<mi> poly_prod(const V<V<mi>> &a,int g){ // b=[a[i]]
    assert(a.size());
    auto cmp=[&](const V<mi> &x,const V<mi> &y){return x.size()>y.size();};
    priority_queue<V<mi>,V<V<mi>>,decltype(cmp)>q(cmp);
    for(const auto &i:a)q.push(i);
    while(q.size()>1){
        V<mi>x=q.top();q.pop();
        V<mi>y=q.top();q.pop();
        q.push(poly_conv_add(x,y,g));
    }
    return q.top();
}

inline V<mi> poly_multi_pt_sum(const V<mi> &a,int m,int g){ // b[i]=sum(a[j]^i)
    ↪ for i in [0,m]
    int n=a.size();
    assert(n);
    V<V<mi>>b(max(n,m));
    For(i,max(n,m))b[i]={1,-a[i]};
    V<mi>c=poly_ln(poly_prod(b,g),g);
    c.resize(m+1);
    c[0]=n;
    FOR(i,1,m+1)c[i]*=mod-i;
    return c;
}

```

## trie.hpp

```
struct trie{
    int siz;
    trie *son[2];
    inline trie(){siz=0,son[0]=son[1]=NULL;}
};

void insert(int dep,trie *p,int k){
    ++p->siz;
    if(dep<0)return;
    int nxt=k>>dep&1;
    if(!p->son[nxt])p->son[nxt]=new trie();
    insert(dep-1,p->son[nxt],k);
}

int query(int dep,trie *p,int k,int lim){
    if(!p)return 0;
    if(dep<0)return p->siz;
    int nxt=k>>dep&1;
    if(lim>>dep&1)return
        (p->son[nxt]?p->son[nxt]->siz:0)+query(dep-1,p->son[nxt^1],k,lim);
    return query(dep-1,p->son[nxt],k,lim);
}

void insert(int dep,trie *p1,trie *p2,int k){
    if(p1)p2->siz=p1->siz;
    ++p2->siz;
    if(dep<0)return;
    int nxt=k>>dep&1;
    if(p1)p2->son[nxt^1]=p1->son[nxt^1];
    p2->son[nxt]=new trie();
    insert(dep-1,p1?p1->son[nxt]:NULL,p2->son[nxt],k);
}

int query(int dep,trie *p1,trie *p2,int k){
    if(dep<0)return 0;
    int nxt=k>>dep&1;
    if(p2->son[nxt^1]&&(!p1||!p1->son[nxt^1]||p2->son[nxt^1]->siz>p1->son[nxt^1]-
        >siz))return
        query(dep-1,p1?p1->son[nxt^1]:NULL,p2->son[nxt^1],k)|(1<<dep);
    return query(dep-1,p1?p1->son[nxt]:NULL,p2->son[nxt],k);
}
```

## vector.hpp

```
template<class T>
inline V<V<T>>> rot(const V<V<T>>>& v){
    V<V<T>>>ret(v[0].size(),V<T>(v.size()));
    For(i,v.size())
        For(j,v[0].size())
            ret[j][v.size()-i-1]=v[i][j];
    return ret;
}

inline ll contor(const V<int>& v){
    int d=*min_element(ALL(v)),n=v.size();
    V<bool>vis(n);
```

```

    for(int i:v)vis[i-d]=true;
    if(any_of(ALL(vis),[](bool b){return !b;}))return -1;
    V<ll>fac(n);
    fac[0]=1;
    BIT3<int>t(n);
    FOR(i,1,n+1){
        if(i<n)fac[i]=fac[i-1]*i;
        ++t.c[i];
        if(i+(i&-i)<=n)t.c[i+(i&-i)]+=t.c[i];
    }
    ll ret=0;
    For(i,n){
        t.add(v[i]-d,-1);
        ret+=fac[n-i-1]*t.query(v[i]-d);
    }
    return ret;
}
inline V<int> inv_contor(int n,ll k){
    V<ll>fac(n+1);
    fac[0]=1;
    FOR(i,1,n+1)fac[i]=fac[i-1]*i;
    if(k>=fac[n])return {-1};
    V<int>ret(n);
    V<bool>vis(n);
    For(i,n){
        int dgt=k/fac[n-i-1]+1,j=-1;
        k%=fac[n-i-1];
        do dgt-=!vis[++j];while(dgt);
        ret[i]=j,vis[j]=true;
    }
    return ret;
}

```

## 哈希.hpp

```

template<int base=2333>
struct mhsh{
    // 0-indexed
    V<ull>bs,h;
    inline mhsh(){}
    inline mhsh(const string &s){
        bs.reserve(s.size()),h.reserve(s.size());
        bs.pb(1),h.pb(s[0]);
        FOR(i,1,s.size())bs.pb(bs.back()*base),h.pb(h.back()*base+s[i]);
    }
    inline mhsh(const V<int> &v){
        bs.reserve(v.size()),h.reserve(v.size());
        bs.pb(1),h.pb(v[0]);
        FOR(i,1,v.size())bs.pb(bs.back()*base),h.pb(h.back()*base+v[i]);
    }
    inline ull get(int l,int r){
        assert(0<=l),assert(l<=r),assert(r<h.size());
        return h[r]-(l?h[l-1]*bs[r-l+1]:0);
    }
}

```

```

inline int lcp(int x,int y){
    assert(0<=min(x,y)),assert(max(x,y)<h.size());
    int l=1,r=h.size()-max(x,y),ret=0;
    while(l<=r){
        int mid=l+r>>1;
        if(get(x,x+mid-1)==get(y,y+mid-1))l=mid+1,ret=mid;
        else r=mid-1;
    }
    return ret;
}

};

template<int base=2337,int mod=998244853>
struct modhsh{
    // 0-indexed
    V<ull>bs,h;
    inline modhsh(){}
    inline modhsh(const string &s){
        bs.reserve(s.size()),h.reserve(s.size());
        bs.pb(1),h.pb(s[0]);
        FOR(i,1,s.size())bs.pb(bs.back()*base%mod),h.pb((h.back()*base+s[i])%mod);
    }
    inline modhsh(const V<int> &v){
        bs.reserve(v.size()),h.reserve(v.size());
        bs.pb(1),h.pb(v[0]);
        FOR(i,1,v.size())bs.pb(bs.back()*base%mod),h.pb((h.back()*base+v[i])%mod);
    }
    inline ull get(int l,int r){
        assert(0<=l),assert(l<=r),assert(r<h.size());
        ull ret=h[r]+mod-(l?h[l-1]*bs[r-l+1]%mod:0);
        return ret>=mod?ret-mod:ret;
    }
};

template<int base1=2337,int mod1=998244853,int base2=2333,int mod2=1'000'000'009>
struct dmhsh{
    // 0-indexed
    modhsh<base1,mod1>hsh1;
    modhsh<base2,mod2>hsh2;
    inline dmhsh(const string &s){
        hsh1=modhsh<base1,mod1>(s),hsh2=modhsh<base2,mod2>(s);
    }
    inline dmhsh(const V<int> &v){
        hsh1=modhsh<base1,mod1>(v),hsh2=modhsh<base2,mod2>(v);
    }
    inline pair<ull,ull> get(int l,int r){
        assert(0<=l),assert(l<=r),assert(r<hsh1.h.size());
        return {hsh1.get(l,r),hsh2.get(l,r)};
    }
    inline int lcp(int x,int y){
        assert(0<=min(x,y)),assert(max(x,y)<hsh2.h.size());
        int l=1,r=hsh2.h.size()-max(x,y),ret=0;
        while(l<=r){
            int mid=l+r>>1;
            if(get(x,x+mid-1)==get(y,y+mid-1))l=mid+1,ret=mid;

```



```

        else r=mid-1;
    }
    return ret;
}
};

mt19937 rnd(time(0));
inline int genPri(int l,int r){
    auto isp=[&](int k){
        if(k<2)return false;
        for(int i=2;i*i<=k;++i)if(k%i==0)return false;
        return true;
    };
    int p=uniform_int_distribution<int>(l,r)(rnd);
    while(!isp(p))++p;
    return p;
};
struct rndhsh{
    // 0-indexed
    int base,mod;
    V<ull>bs,h;
    inline rndhsh(){base=genPri(2,1e5),mod=genPri(2,1e9);}
    inline rndhsh(const string &s){
        bs.reserve(s.size()),h.reserve(s.size());
        bs.pb(1),h.pb(s[0]);
        FOR(i,1,s.size())bs.pb(bs.back()*base%mod),h.pb((h.back()*base+s[i])%mod);
    }
    inline rndhsh(const V<int> &v){
        bs.reserve(v.size()),h.reserve(v.size());
        bs.pb(1),h.pb(v[0]);
        FOR(i,1,v.size())bs.pb(bs.back()*base%mod),h.pb((h.back()*base+v[i])%mod);
    }
    inline ull get(int l,int r){
        assert(0<=l),assert(l<=r),assert(r<h.size());
        ull ret=h[r]+mod-(l?h[l-1]*bs[r-l+1]%mod:0);
        return ret>=mod?ret-mod:ret;
    }
};
struct drhsh{
    // 0-indexed
    rndhsh hsh1;
    rndhsh hsh2;
    inline drhsh(const string &s){
        hsh1=rndhsh(s),hsh2=rndhsh(s);
    }
    inline drhsh(const V<int> &v){
        hsh1=rndhsh(v),hsh2=rndhsh(v);
    }
    inline pair<ull,ull> get(int l,int r){
        assert(0<=l),assert(l<=r),assert(r<hsh1.h.size());
        return {hsh1.get(l,r),hsh2.get(l,r)};
    }
    inline int lcp(int x,int y){
        assert(0<=min(x,y)),assert(max(x,y)<hsh2.h.size());

```

```

    int l=1,r=hsh2.h.size()-max(x,y),ret=0;
    while(l<=r){
        int mid=l+r>>1;
        if(get(x,x+mid-1)==get(y,y+mid-1))l=mid+1,ret=mid;
        else r=mid-1;
    }
    return ret;
}
};

```

## 图论.hpp

```

inline V<ll> bfs01(int n,int s,const V<V<pii>> &to){
    assert(0<=n),assert(0<=s),assert(s<n),assert(to.size()<=n);
    for(const V<pii> &i:to)
        for(const pii &j:i)
            assert(0<=min(j.fi,j.se)),assert(j.fi<n);
    V<ll>dis(n,infl);
    dis[s]=0;
    deque<int>q;
    q.pb(s);
    V<bool>vis(n); // added vis to prevent an obvious error
    while(q.size()){
        int p=q.front();q.qf();
        if(vis[p])continue;
        vis[p]=true;
        for(const pii
            ↪ &i:to[p])if(ckmin(dis[i.fi],dis[p]+i.se))i.se?q.pb(i.fi):q.pf(i.fi);
    }
    for(ll &i:dis)if(i==infl)i=-1;
    return dis;
}

template<class T>
inline V<ll> dijkstra(int n,int s,const V<V<pair<int,T>>> &to,ll null=-1){
    V<ll>dis(n,infl);
    dis[s]=0;
    typedef pair<int,ll> pil;
    auto cmp=[&](const pil &x,const pil &y){return x.se>y.se;};
    priority_queue<pil,V<pil>,decltype(cmp)>q(cmp);
    q.emplace(s,0);
    V<bool>vis(n);
    while(q.size()){
        int p=q.top().fi;q.pop();
        if(vis[p])continue;
        vis[p]=true;
        for(const auto
            ↪ &[i,j]:to[p])if(ckmin(dis[i],dis[p]+j)&&!vis[i])q.emplace(i,dis[i]);
    }
    for(ll &i:dis)if(i==infl)i=null;
    return dis;
}

```

```

inline V<array<int,3>> kruskal(int n,const V<pii>> &to,function<bool(const
↪ array<int,3> &,const array<int,3> &>cmp=[](const array<int,3> x,const
↪ array<int,3> &y){return x[2]<y[2];}){
    assert(0<=n),assert(to.size()<=n);
    for(const V<pii> &i:to)for(const pii &j:i)assert(j.fi<n);
    V<array<int,3>>e;
    For(i,to.size())for(const pii
↪ &j:to[i])assert(0<=j.fi),assert(j.fi<n),e.pb({i,j.fi,j.se});
    sort(ALL(e),cmp);
    dsu d(n);
    V<array<int,3>>ret;
    for(auto &i:e)if(d.merge(i[0],i[1]))ret.pb(i);
    return ret;
}

struct ring{
    int clr;
    V<int>id;
    V<V<int>>>scc,to;
    inline void init(const V<V<int>>>&to){
        int cnt=clr=0,n=to.size();
        V<bool>cur(n);
        V<int>dfn(n),low(n);
        V<int>(n,-1).swap(id),V<V<int>>>().swap(scc);
        stack<int>st;
        function<void(int)>tarjan=[&](int p){
            cur[p]=true;
            dfn[p]=low[p]=++cnt;
            st.push(p);
            for(int i:to[p]){
                assert(0<=i&&i<n);
                if(!dfn[i])tarjan(i),ckmin(low[p],low[i]);
                else if(cur[i])ckmin(low[p],dfn[i]);
            }
            if(dfn[p]==low[p]){
                scc.pb(V<int>());
                int k;
                do{
                    k=st.top();st.pop();
                    cur[k]=false,id[k]=clr,scc[clr].pb(k);
                }while(k!=p);
                ++clr;
            }
        };
        For(i,n)if(!dfn[i])tarjan(i);
        V<int>lst(clr,-1);
        V<V<int>>>(clr).swap(this->to);
        For(i,clr){
            lst[i]=i;
            for(int j:scc[i])for(int
↪ k:to[j])if(lst[id[k]]!=i)lst[id[k]]=i,this->to[i].pb(id[k]);
        }
    }
    inline ring(const V<V<int>>>&to){init(to);}
}

```

```

    inline ring(){}
};

struct vDCC{
    int clr;
    V<bool>cut;
    V<V<int>>>dcc,to;
    inline void init(const V<V<int>>>&to){
        int cnt=0,n=clr=to.size();
        V<int>dfn(n),low(n);
        V<bool>(n).swap(cut),V<V<int>>>().swap(dcc);
        V<V<int>>>(n).swap(this->to);
        For(i,n)
            if(!dfn[i]){
                stack<int>st;
                function<void(int,int)>tarjan=[&](int p,int fa){
                    dfn[p]=low[p]=++cnt;
                    int flag_son=0;
                    st.push(p);
                    for(int i:to[p]){
                        assert(0<=i&&i<n);
                        if(!dfn[i]){
                            tarjan(i,p),ckmin(low[p],low[i]);
                            if(low[i]>=dfn[p]){
                                if(fa!=-1||flag_son++)cut[p]=true;
                                this->dcc.pb(V<int>()),this->to.pb(V<int>());
                                int k;
                                do{
                                    k=st.top();st.pop();
                                    this->dcc.back().pb(k);
                                    this->to[k].pb(clr),this->to[clr].pb(k);
                                }while(k!=i);
                                this->dcc.back().pb(p);
                                this->to[p].pb(clr),this->to[clr++].pb(p);
                            }
                        }
                        else ckmin(low[p],dfn[i]);
                    }
                    if(!~fa&&!flag_son)this->dcc.pb({p});
                };
                tarjan(i,-1);
            }
    }
    inline vDCC(const V<V<int>>>&to){init(to);}
    inline vDCC(){}
};

struct eDCC{
    int clr;
    V<V<int>>>dcc,to;
    V<int>id;
    inline void init(const V<V<int>>>&to){
        int cnt=clr=0,n=to.size();
        V<int>dfn(n),low(n);

```

```

V<V<int>>().swap(dcc),V<int>(n,-1).swap(id);
stack<int>st;
function<void(int,int)>tarjan=[&](int p,int fa){
    dfn[p]=low[p]++;cnt;
    bool flag=false;
    st.push(p);
    for(int i:to[p]){
        if(i!=fa){
            if(!dfn[i])tarjan(i,p),ckmin(low[p],low[i]);
            else ckmin(low[p],dfn[i]);
        }
        if(i==fa){
            if(flag)ckmin(low[p],dfn[i]);
            else flag=true;
        }
    }
    if(dfn[p]<=low[p]){
        dcc.pb(V<int>());
        int k;
        do{
            k=st.top();st.pop();
            id[k]=clr,dcc[clr].pb(k);
        }while(k!=p);
        ++clr;
    }
};
For(i,n)if(!dfn[i])tarjan(i,-1);
V<int>lst(clr,-1);
V<V<int>>(clr).swap(this->to);
For(i,clr){
    lst[i]=i;
    for(int j:dcc[i])for(int
        ↪ k:to[j])if(lst[id[k]]!=i)lst[id[k]]=i,this->to[i].pb(id[k]);
}
}
inline eDCC(const V<V<int>>&to){init(to);}
inline eDCC(){}
};

struct range_2sat{
    int n;
    V<V<int>>to;
    inline int idx(int l,int r){return (l+r|l!=r)>>1;}
    #define p idx(l,r)
    inline void resize(int n_){
        n=n_;
        V<V<int>>((n<<1)+(n-1<<2)).swap(to);
        function<int(int,int,int)>build_dw=[&](int l,int r,int k){
            if(l==r)return (k&1)*n+l;
            int mid=l+r>>1;
            to[(n<<1)+k*(n-1)+p].pb(build_dw(l,mid,k));
            to[(n<<1)+k*(n-1)+p].pb(build_dw(mid+1,r,k));
            return (n<<1)+k*(n-1)+p;
        };
};

```

```

    build_dw(0,n-1,0),build_dw(0,n-1,1);
    function<int(int,int,int)>build_up=[&](int l,int r,int k){
        if(l==r) return (k&1)*n+r;
        int mid=l+r>>1;
        to[build_up(l,mid,k)].pb((n<<1)+k*(n-1)+p);
        to[build_up(mid+1,r,k)].pb((n<<1)+k*(n-1)+p);
        return (n<<1)+k*(n-1)+p;
    };
    build_up(0,n-1,2),build_up(0,n-1,3);
}
inline range_2sat(){}
inline range_2sat(int n_){resize(n_);}
inline V<int> range_dw(int ql,int qr,int k){
    V<int>ret;
    function<void(int,int)>dfs=[&](int l,int r){
        if(ql<=l&&r<=qr){
            if(l==r) ret.pb(k*n+l);
            else ret.pb((n<<1)+k*(n-1)+p);
            return;
        }
        int mid=l+r>>1;
        if(ql<=mid)dfs(l,mid);
        if(qr>mid)dfs(mid+1,r);
    };
    dfs(0,n-1);
    return ret;
}
inline V<int> range_up(int ql,int qr,int k){
    V<int>ret;
    function<void(int,int)>dfs=[&](int l,int r){
        if(ql<=l&&r<=qr){
            if(l==r) ret.pb(k*n+r);
            else ret.pb((n<<1)+(k+2)*(n-1)+p);
            return;
        }
        int mid=l+r>>1;
        if(ql<=mid)dfs(l,mid);
        if(qr>mid)dfs(mid+1,r);
    };
    dfs(0,n-1);
    return ret;
}
#undef p
inline void link_pp(int x,int y,bool op_x,bool op_y,bool rev=true){
    to[op_x*n+x].pb(op_y*n+y);
    if(rev) to[(op_y^1)*n+y].pb((op_x^1)*n+x);
}
inline void link_pr(int x,int yl,int yr,bool op_x,bool op_y,bool rev=true){
    for(int y:range_dw(yl,yr,op_y))to[op_x*n+x].pb(y);
    if(rev)for(int y:range_up(yl,yr,op_y^1))to[y].pb((op_x^1)*n+x);
}
inline void link_rp(int xl,int xr,int y,bool op_x,bool op_y,bool rev=true){
    for(int x:range_up(xl,xr,op_x))to[x].pb(op_y*n+y);
    if(rev)for(int x:range_dw(xl,xr,op_x^1))to[(op_y^1)*n+y].pb(x);
}

```

```

}
inline void link_rr(int xl,int xr,int yl,int yr,bool op_x,bool op_y,bool
↪ rev=true){
    V<int>X=range_up(xl,xr,op_x);
    for(int y:range_dw(yl,yr,op_y))for(int x:X)to[x].pb(y);
    if(rev){
        V<int>Y=range_up(yl,yr,op_y^1);
        for(int x:range_dw(xl,xr,op_x^1))for(int y:Y)to[y].pb(x);
    }
}
};

```

## 堆.hpp

```

template<class T,class U=less<T>>
struct delpq{
    priority_queue<T,V<T>,U>q1,q2;
    inline delpq(){}
    inline delpq(const U &func){priority_queue<T,V<T>,U>(func).swap(q1),
↪ priority_queue<T,V<T>,U>(func).swap(q2);}
    inline void push(const T &x){q1.push(x);}
    inline void pop(const T &x){q2.push(x);}
    inline T top(){
        while(q2.size()&&q1.top()==q2.top())q1.pop(),q2.pop();
        assert(q1.size());
        return q1.top();
    }
    inline bool empty(){return q1.size()==q2.size();}
    inline int size(){assert(q1.size()>=q2.size());return q1.size()-q2.size();}
};

template<class T>
struct kpq{
    int k;
    multiset<T>s1,s2;
    ll sum;
    inline kpq(int _k=0):k(_k),sum(0){}
    inline void insert(const T &x){
        if(s1.size()<k)s1.insert(x),sum+=x;
        else{
            if(x>*s1.begin())s2.insert(*s1.begin()),sum-=*s1.begin(),s1.erase(s1.
↪ begin()),s1.insert(x),sum+=x;
            else s2.insert(x);
        }
    }
    inline void erase(const T &x){
        if(s1.size()&&x<*s1.begin()){
            auto it=s2.find(x);
            assert(it!=s2.end());
            s2.erase(it);
        }
        else{
            auto it=s1.find(x);

```

```

        assert(it!=s1.end());
        s1.erase(it);
        sum-=x;
        if(s1.size()<k&& s2.size())s1.insert(*s2.rbegin()),sum+=*s2.rbegin(),
        ↪ s2.erase(prev(s2.end()));
    }
}
};

```

## 字符串.hpp

```

inline int lcs(const string &a,const string &b){
    if(a.empty()||b.empty())return 0;
    int n=a.size(),m=b.size(),k=(n+62)/63;
    V<ull>f(k);
    char mn=*min_element(ALL(a)),mx=*max_element(ALL(a));
    V<V<ull>>g(mx-mn+1,V<ull>(k));
    For(i,n)g[a[i]-mn][i/63]|=1ull<<i%63;
    for(char i:b){
        if(i<mn||i>mx)continue;
        i-=mn;
        ull z=1;
        For(j,k){
            ull x=f[j],y=f[j]|g[i][j];
            ((x<=1)|=z)+=(~y)&((1ull<<63)-1);
            f[j]=x&y,z=x>>63;
        }
    }
    return accumulate(ALL(f),0,[&](int x,ull y){return
    ↪ x+__builtin_popcountll(y);});
}

template<class T>
inline int lcs(const V<T> &a,const V<T> &b){
    if(a.empty()||b.empty())return 0;
    int n=a.size(),m=b.size(),k=(n+62)/63;
    disc<T>d(a);
    V<ull>f(k);
    V<V<ull>>g(d.size(),V<ull>(k));
    For(i,n)g[d.query(a[i])][i/63]|=1ull<<i%63;
    for(const T &i:b){
        auto it=lower_bound(ALL(d.d),i);
        if(it==d.d.end()||*it!=i)continue;
        i=it-d.d.begin();
        ull z=1;
        For(j,k){
            ull x=f[j],y=f[j]|g[i][j];
            ((x<=1)|=z)+=(~y)&((1ull<<63)-1);
            f[j]=x&y,z=x>>63;
        }
    }
    return accumulate(ALL(f),0,[&](int x,ull y){return
    ↪ x+__builtin_popcountll(y);});
}

```



```

struct subseq_table{
    V<V<int>>nxt;
    inline subseq_table(const string &v){
        int n=v.size();
        V<V<int>>(128).swap(nxt);
        For(i,n){
            assert(v[i]>=0&&v[i]<128);
            nxt[v[i]].pb(i);
        }
    }
    inline int lcp(const string &v){
        int nw=0,ret=0;
        for(char i:v){
            assert(i>=0&&i<128);
            auto it=lower_bound(ALL(nxt[i]),nw);
            if(it==nxt[i].end())break;
            nw=*it+1,++ret;
        }
        return ret;
    }
    inline bool query(const string &v){
        return lcp(v)==v.size();
    }
};

template<class T,class container=unordered_map<T,int>>
struct subseq_Table{
    genID<T,container>g;
    V<V<int>>nxt;
    inline subseq_Table(const V<T> &v){
        int n=v.size();
        For(i,n){
            int k=g.get_id(v[i]);
            if(k>=nxt.size())nxt.pb(V<int>());
            nxt[k].pb(i);
        }
    }
    inline int lcp(const V<T> &v){
        int nw=0,ret=0;
        for(const T &i:v){
            if(!g.count(i))break;
            int k=g.get_id(i);
            auto it=lower_bound(ALL(nxt[k]),nw);
            if(it==nxt[k].end())break;
            nw=*it+1,++ret;
        }
        return ret;
    }
    inline bool query(const V<T> &v){
        return lcp(v)==v.size();
    }
};

struct manacher{

```

```

int n;
V<int>p;
inline manacher(const string &s){
    n=s.size();
    p.assign(n<<1|1,1);
    string t(n<<1|1,'#');
    For(i,n)t[i<<1|1]=s[i];
    for(int i=0,mid=-1,mx=-1;i<p.size();++i){
        if(i<=mx)p[i]=min(p[(mid<<1)-i],mx-i)+1;
        while(i>=p[i]&&i+p[i]<p.size()&&t[i-p[i]]==t[i+p[i]])++p[i];
        if(i+-p[i]>mx)mid=i,mx=i+p[i];
    }
}
inline int odd(int k){
    assert(0<=k&&k<n);
    return p[k<<1|1];
}
inline int even(int k){
    assert(0<=k&&k+1<n);
    return p[k+1<<1];
}
inline bool isp(int l,int r){
    assert(0<=l),assert(l<=r),assert(r<n);
    return p[l+r+1]>=r-l+1;
}
};

inline V<int> get_kmp(const string &s){
    int n=s.size();
    V<int>kmp(n);
    for(int i=1,j=0;i<n;++i){
        while(j&&s[j]!=s[i])j=kmp[j-1];
        if(s[j]==s[i])++j;
        kmp[i]=j;
    }
    return kmp;
}
inline V<int> find_kmp(const V<int> &kmp,const string &s,const string &t){
    int n=s.size(),m=t.size();
    V<int>ret;
    for(int i=0,j=0;i<n;++i){
        while(j&&t[j]!=s[i])j=kmp[j-1];
        if(t[j]==s[i])++j;
        if(j==m)ret.pb(i);
    }
    return ret;
}
}

```

## 并查集.hpp

```

struct dsu{
    V<int>fa;
    inline void resize(int n){V<int>(n,-1).swap(fa);}
    inline dsu(int n=0){resize(n);}
}

```

```

int find(int k){return fa[k]<0?k:fa[k]=find(fa[k]);}
inline bool merge(int x,int y){
    x=find(x),y=find(y);
    if(x!=y)fa[x]+=fa[y],fa[y]=x;
    return x!=y;
}
inline bool same(int x,int y){return find(x)==find(y);}
inline int size(int k){return -fa[find(k)];}
};
inline pair<V<V<int>>,V<int>> kruskal_tree(int n,V<array<int,3>> &e){
    int cnt=n;
    dsu d(n+n-1);
    V<V<int>>to(n+n-1);
    V<int>val(n+n-1);
    sort(ALL(e),[&](const auto &x,const auto &y){return x[2]<y[2];});
    for(const auto &i:e){
        int fx=d.find(i[0]),fy=d.find(i[1]);
        if(fx!=fy){
            d.fa[fx]=d.fa[fy]=cnt;
            to[cnt].pb(fx),to[cnt].pb(fy);
            val[cnt++]=i[2];
        }
    }
    assert(cnt==n+n-1);
    return {to,val};
}

struct range_dsu{
    V<V<int>>fa;
    int lg,n;
    inline void resize(int _n){
        V<V<int>>(lg=((n=_n)?__lg(n):-1)+1).swap(fa);
        For(i,lg)fa[i].resize(n-(1<<i)+1,-1);
    }
    inline range_dsu(int _n=0){resize(_n);}
    int find(int d,int k){return fa[d][k]<0?k:fa[d][k]=find(d,fa[d][k]);}
    inline void merge(int d,int x,int y){
        x=find(d,x),y=find(d,y);
        if(x>y)swap(x,y);
        if(x!=y)fa[d][x]+=fa[d][y],fa[d][y]=x;
    }
    inline void merge(int x1,int x2,int y1,int y2){
        assert(x2-x1==y2-y1);
        Rep(i,lg)if(x1+(1<<i)-1<=x2){
            merge(i,x1,y1);
            x1+=1<<i,y1+=1<<i;
        }
    }
    inline void init(){
        REP(i,1,lg)For(j,n-(1<<i)+1){
            int k=find(i,j);
            merge(i-1,j,k),merge(i-1,j+(1<<i-1),k+(1<<i-1));
        }
    }
}

```

```

    int find(int k){return fa[0][k]<0?k:fa[0][k]=find(fa[0][k]);}
    inline bool same(int x,int y){return find(x)==find(y);}
    inline int size(int k){return -fa[0][find(k)];}
};

```

## 数论.hpp

*// assumed that [mod<=INT\_MAX] is true*

```

template<class T>
T exgcd(const T &a,const T &b,T &x,T &y){
    if(!b){x=1,y=0;return a;}
    T g=exgcd(b,a%b,y,x);
    y-=a/b*x;
    return g;
};

template<class T>
inline T inv_exgcd(T n,T p=mod){
    // n*inv = 1 (mod p)
    // n*inv + p*k = 1
    // a*x + b*y = 1
    T inv=0,tmp=0;
    exgcd(n,p,inv,tmp);
    return inv<0?inv+p:inv;
}

template<class T>
inline ll exCRT(const V<T> &a,const V<T> &m){
    int n=a.size();
    assert(n==m.size());
    For(i,n)assert(0<=a[i]&&0<m[i]);
    function<ll(ll,ll,ll)>mul=[&](ll x,ll y,ll p=mod){
        ll z=0;
        auto add=[&](ll x,ll y){return x+y>=p?x+y-p:x+y;};
        for(x%=p;y;x=add(x,x),y>=1)(y&1)&&(z=add(z,x));
        return z;
    };
    ll md=m[0],ret=a[0],x,y;
    FOR(i,1,n){
        ll g=exgcd(md,(ll)m[i],x,y),res=a[i]-ret%m[i];
        if(res<0)res+=m[i];
        if(res%g)return -1;
        ll mg=m[i]/g;
        if(x<0)x+=m[i];
        ret+=(x=mul(x,res/g,mg))*md;
        ret%=(md*=mg);
        if(ret<0)ret+=md;
    }
    return ret;
}

inline V<int> inverse(int n,int p=mod){
    V<int>inv(n+1);
    inv[1]=1;
    FOR(i,2,n+1)inv[i]=1ll*(p-p/i)*inv[p%i]%p;
}

```

```

    return inv;
}

inline V<V<int>> comb(int n,int m=-1,int p=mod){
    if(m==-1)m=n;
    if(n<m||m<0) return V<V<int>>();
    V<V<int>> C(n+1,V<int>(m+1));
    For(i,n+1){
        C[i][0]=1;
        FOR(j,1,min(i+1,m+1)){
            C[i][j]=C[i-1][j-1]+C[i-1][j];
            if(C[i][j]>=p)C[i][j]-=p;
        }
    }
    return C;
}

struct comb_table{
    int n;
    V<mi>fac,ifac;
    inline comb_table(int n_=0){n=n_,init();}
    inline void init(){
        V<mi>(n+1).swap(fac),V<mi>(n+1).swap(ifac);
        fac[0]=1;
        FOR(i,1,n+1)fac[i]=fac[i-1]*i;
        ifac[n]=1/fac[n];
        Rep(i,n)ifac[i]=ifac[i+1]*(i+1);
    }
    inline mi C(int x,int y){return x<y||y<0?0:fac[x]*ifac[y]*ifac[x-y];}
};

struct pri_table{
    int n;
    // fac[i] is the minimum prime factor of i
    V<int>fac,pri;
    inline pri_table(int n_=0){n=n_,init();}
    inline void init(){
        if(n<1) return;
        V<int>(n+1).swap(fac),V<int>().swap(pri);
        fac[1]=1;
        FOR(i,2,n+1){
            if(!fac[i])fac[i]=i,pri.pb(i);
            for(int j:pri){
                if(i*j>n)break;
                fac[i*j]=j;
                if(i%j==0)break;
            }
        }
    }
    inline bool isp(int k){return k<2?false:(fac[k]==k);}
    inline V<int> div(int k){
        assert(k<=n);
        if(k<2) return V<int>();
        V<int>ret;

```

```

        while(k>1){
            int f=fac[k];
            do k/=f;while(k%f==0);
            ret.pb(f);
        }
        return ret;
    }
};

struct mu_table{
    int n;
    V<int>mu,pri;
    V<bool>vis;
    inline mu_table(int n_=0){n=n_,init();}
    inline void init(){
        if(n<1) return;
        V<int>(n+1).swap(mu),V<int>().swap(pri),V<bool>(n+1).swap(vis);
        mu[1]=1;
        FOR(i,2,n+1){
            if(!vis[i])mu[i]=-1,pri.pb(i);
            for(int j:pri){
                if(i*j>n)break;
                vis[i*j]=true;
                if(i%j==0)break;
                mu[i*j]=-mu[i];
            }
        }
    }
    inline int get(int k){return k<1?0:mu[k];}
};

struct phi_table{
    int n;
    V<int>phi,pri;
    inline phi_table(int n_=0){n=n_,init();}
    inline void init(){
        if(n<1) return;
        V<int>(n+1).swap(phi),V<int>().swap(pri);
        phi[1]=1;
        FOR(i,2,n+1){
            if(!phi[i])phi[i]=i-1,pri.pb(i);
            for(int j:pri){
                if(i*j>n)break;
                if(i%j==0){
                    phi[i*j]=phi[i]*j;
                    break;
                }
                phi[i*j]=phi[i]*(j-1);
            }
        }
    }
    inline int get(int k){return k<1?0:phi[k];}
};

```

```

struct d_table{
    int n;
    V<int>cnt,d,pri;
    V<bool>vis;
    inline d_table(int n_=0){n=n_,init();}
    inline void init(){
        if(n<1) return;
        V<int>(n+1).swap(cnt),V<int>(n+1).swap(d),V<int>().swap(pri),V<bool>(n+1)
        ↪ ).swap(vis);
        cnt[1]=d[1]=1;
        FOR(i,2,n+1){
            if(!vis[i])cnt[i]=1,d[i]=2,pri.pb(i);
            for(int j:pri){
                if(i*j>n)break;
                vis[i*j]=true;
                if(i%j==0){
                    int &x=cnt[i*j];
                    x=cnt[i]+1;
                    d[i*j]=d[i]/x*(x+1);
                    break;
                }
                cnt[i*j]=1,d[i*j]=d[i]<<1;
            }
        }
    }
    inline int get(int k){return k<1?0:d[k];}
};

inline mi lagrange(int l,const V<mi> &y,int x){
    assert(y.size());
    int n=y.size();
    if(n==1)return y[0];
    if(l<=x&&x<l+n)return y[x-l];
    int r=l+n-1;
    r%=mod;if(r<0)r+=mod;
    x%=mod;if(x<0)x+=mod;
    if(r>=x&&x>r-n)return y[n-(r-x)-1];
    V<mi>ifac(n);
    ifac[0]=ifac[1]=1;
    FOR(i,2,n)ifac[i]=(mod-mod/i)*ifac[mod%i];
    FOR(i,2,n)ifac[i]*=ifac[i-1];
    V<mi>suf(n);
    suf[n-1]=1;
    REP(i,1,n)suf[i-1]=suf[i]*(x+mod-r+n-1-i);
    mi pre=1,ret=0;
    For(i,n){
        if((n-i)&1)ret+=y[i]*pre*suf[i]*ifac[i]*ifac[n-1-i];
        else ret-=y[i]*pre*suf[i]*ifac[i]*ifac[n-1-i];
        pre*=x+mod-r+n-1-i;
    }
    return ret;
}

inline mi sumexp(int n,int k){
    assert(min(n,k)>=0);

```

```

V<int> pri;
V<mi> pw(k+2);
pw[0]=!k, pw[1]=1;
FOR(i, 2, k+2){
    if(!pw[i]) pri.pb(i), pw[i]=mi(i)^k;
    for(int j: pri){
        if(i*j>k+1) break;
        pw[i*j]=pw[i]*pw[j];
        if(i%j==0) break;
    }
}
FOR(i, 2-!k, k+2) pw[i]+=pw[i-1];
return lagrange(0, pw, n);
}

/*
pre_f=sum(mu) pre_g=n pre_fg=1
pre_f=sum(phi) pre_g=n pre_fg=n*(n+1)/2
pre_f=sum(phi*id) pre_g=n*(n+1)/2 pre_fg=n*(n+1)*(2n+1)/6
*/
template<class T, class container>
T du_sieve(T n, const V<T> &pre_f, const function<T(T)> &pre_g, const function<T(T)>
    &pre_fg, container &h){
    if(n<pre_f.size()) return pre_f[n];
    auto it=h.emplace(n, 0);
    T &x=it.fi->se;
    if(it.se){
        T pre=pre_g(1);
        x=pre_fg(n);
        for(T i=2; i<=n; ++i){
            T div=n/i, j=n/div, cur=pre_g(j);
            x-=(cur-pre)*du_sieve(div, pre_f, pre_g, pre_fg, h);
            i=j, pre=cur;
        }
    }
    return x;
}

struct vote_1{
    pii v;
    inline vote_1(){v={-1, 0};}
    inline vote_1(int id, int cnt=1){v={id, cnt};}
    inline vote_1 operator+(const vote_1 &rhs){
        vote_1 ret=*this;
        if(!~ret.v.fi) ret=rhs;
        else if(~rhs.v.fi){
            if(ret.v.fi==rhs.v.fi) ret.v.se+=rhs.v.se;
            else{
                if(ret.v.se<rhs.v.se) ret={rhs.v.fi, rhs.v.se-ret.v.se};
                else ret.v.se-=rhs.v.se;
            }
        }
        return ret;
    }
}

```



```

};

template<int (*n)()>
struct vote{
    V<pii>v;
    inline vote(){V<pii>(n(),{-1,0}).swap(v);}
    inline vote(int id,int cnt=1){V<pii>(n(),{-1,0}).swap(v),v[0]={id,cnt};}
    inline vote operator+(const vote<n> &rhs){
        vote<n>ret=*this;
        for(pii i:rhs.v){
            if(!i.fi)break;
            for(pii &j:ret.v)if(!j.fi||i.fi==j.fi){
                j.fi=i.fi,j.se+=i.se;
                goto skip;
            }
            for(pii &j:ret.v)if(i.se>j.se)swap(i,j);
            for(pii &j:ret.v)j.se-=i.se;
            skip:;
        }
        return ret;
    }
};

template<int w2>
struct fp2{
    mi a,b;
    inline fp2(mi _a=0,mi _b=0):a(_a),b(_b){}
    inline fp2 operator+(mi rhs)const{return fp2(a+rhs,b);}
    inline fp2 operator-(mi rhs)const{return fp2(a-rhs,b);}
    inline fp2 operator*(mi rhs)const{return fp2(a*rhs,b*rhs);}
    inline fp2 operator/(mi rhs)const{mi inv=1/rhs;return fp2(a*inv,b*inv);}
    inline fp2 operator^(int k)const{fp2
        ↪ pw=*this,ret(1);for(;k;k>=1,pw=pw*pw)if(k&1)ret=ret*pw;return ret;}
    inline fp2& operator+=(mi rhs){a+=rhs;return *this;}
    inline fp2& operator-=(mi rhs){a-=rhs;return *this;}
    inline fp2& operator*=(mi rhs){a*=rhs,b*=rhs;return *this;}
    inline fp2& operator/=(mi rhs){mi inv=1/rhs;a*=inv,b*=inv;return *this;}
    inline fp2& operator^(int k){fp2
        ↪ tmp(1),base=*this;for(;k;k>=1,base*=base)if(k&1)tmp*=base;return
        ↪ *this=tmp;}
    inline fp2 operator+(const fp2&rhs)const{return fp2(a+rhs.a,b+rhs.b);}
    inline fp2 operator-(const fp2&rhs)const{return fp2(a-rhs.a,b-rhs.b);}
    inline fp2 operator*(const fp2&rhs)const{return
        ↪ fp2(a*rhs.a+b*rhs.b*w2,a*rhs.b+rhs.a*b);}
    inline fp2 operator/(const fp2&rhs)const{assert(rhs.a.val||rhs.b.val);mi
        ↪ inv=1/(rhs.a*rhs.a-rhs.b*rhs.b*w2);return
        ↪ fp2((a*rhs.a-b*rhs.b*w2)*inv,(rhs.a*b-a*rhs.b)*inv);}
    inline fp2& operator+=(const fp2&rhs){a+=rhs.a,b+=rhs.b;return *this;}
    inline fp2& operator-=(const fp2&rhs){a-=rhs.a,b-=rhs.b;return *this;}
    inline fp2& operator*=(const fp2&rhs){mi
        ↪ x=a*rhs.a+b*rhs.b*w2,y=a*rhs.b+rhs.a*b;a=x,b=y;return *this;}
    inline fp2& operator/=(const fp2&rhs){assert(rhs.a.val||rhs.b.val);mi
        ↪ inv=1/(rhs.a*rhs.a-rhs.b*rhs.b*w2);mi
        ↪ x=(a*rhs.a-b*rhs.b*w2)*inv,y=(rhs.a*b-a*rhs.b)*inv;a=x,b=y;return *this;}
};

```

```

inline fp2 operator-()const{return fp2(-a,-b);}
friend fp2 operator+(mi lhs,const fp2&rhs){return fp2(lhs+rhs.a,rhs.b);}
friend fp2 operator-(mi lhs,const fp2&rhs){return fp2(lhs-rhs.a,-rhs.b);}
friend fp2 operator*(mi lhs,const fp2&rhs){return fp2(lhs*rhs.a,lhs*rhs.b);}
friend fp2 operator/(mi lhs,const fp2&rhs){assert(rhs.a.val||rhs.b.val);mi
↪ inv=1/(rhs.a*rhs.a-rhs.b*rhs.b*w2);return
↪ fp2(lhs*rhs.a*inv,-lhs*rhs.b*inv);}
};

```

## 树.hpp

```

template<class T>
inline V<pii> cart_seq(const V<T> &v,function<bool(T,T)>cmp=[](T x,T y){return
↪ x>y;}){
    int n=v.size();
    V<pii>ret(n,pii(-1,n));
    stack<int>st;
    For(i,n){
        while(st.size()&&cmp(v[i],v[st.top()]))ret[st.top()].se=i-1,st.pop();
        if(st.size())ret[i].fi=st.top()+1;
        st.push(i);
    }
    return ret;
}

template<class T>
inline V<pii> cart_son(const V<T> &v,function<bool(T,T)>cmp=[](T x,T y){return
↪ x>y;}){
    int n=v.size();
    V<pii>ret(n,pii(-1,n));
    stack<int>st;
    For(i,n){
        while(st.size()&&cmp(v[i],v[st.top()]))ret[i].fi=st.top(),st.pop();
        if(st.size())ret[st.top()].se=i;
        st.push(i);
    }
    return ret;
}

struct lca_table{
    int n,rt;
    V<V<int>>>to;
    inline void resize(int n_){V<V<int>>>(n=n_).swap(to);}
    inline lca_table(int n_=0){resize(n_);}
    inline void add_edge(int x,int y){
        assert(0<=x),assert(x<n),assert(0<=y),assert(y<n),assert(x!=y);
        to[x].pb(y),to[y].pb(x);
    }
    inline lca_table(const V<V<int>>>&to_){n=(to=to_).size();init();}
    V<int>dep,fa,siz,son,top;
    inline void init(int _rt=0){
        rt=_rt;
        V<int>(n).swap(dep),V<int>(n).swap(fa),V<int>(n).swap(siz),V<int>(n,-1).
↪ swap(son);
        function<void(int,int)>dfs1=[&](int p,int f){

```

```

        if(~f)dep[p]=dep[f]+1;
        fa[p]=f,siz[p]=1;
        for(int i:to[p])
            if(i!=f){
                dfs1(i,p);
                siz[p]+=siz[i];
                if(!~son[p]||siz[i]>siz[son[p]])son[p]=i;
            }
    };
    V<int>(n,-1).swap(top);
    dfs1(rt,-1);
    function<void(int,int)>dfs2=[&](int p,int k){
        top[p]=k;
        if(~son[p]){
            dfs2(son[p],k);
            for(int i:to[p])
                if(!~top[i])
                    dfs2(i,i);
        }
    };
    dfs2(rt,rt);
}
inline int lca(int x,int y){
    assert(0<=x),assert(x<n),assert(0<=y),assert(y<n);
    while(top[x]!=top[y]){
        if(dep[top[x]]<dep[top[y]])swap(x,y);
        x=fa[top[x]];
    }
    return dep[x]<dep[y]?x:y;
}
};

struct tree_chain{
    int n,rt;
    V<V<int>>>to;
    inline void resize(int n_){V<V<int>>>(n=n_).swap(to);}
    inline tree_chain(int n_=0){resize(n_);}
    inline void add_edge(int x,int y){
        assert(0<=x),assert(x<n),assert(0<=y),assert(y<n),assert(x!=y);
        to[x].pb(y),to[y].pb(x);
    }
    inline tree_chain(const V<V<int>>>&to_){n=(to=to_).size();init();}
    V<int>dep,fa,rev,seg,siz,son,top;
    inline void init(int _rt=0){
        rt=_rt;
        V<int>(n).swap(dep),V<int>(n).swap(fa),V<int>(n).swap(siz),V<int>(n,-1).
        ↪ swap(son);
        function<void(int,int)>dfs1=[&](int p,int f){
            if(~f)dep[p]=dep[f]+1;
            fa[p]=f,siz[p]=1;
            for(int i:to[p])
                if(i!=f){
                    dfs1(i,p);
                    siz[p]+=siz[i];
                }
        };
        dfs1(rt,rt);
    }
};

```

```

        if(!~son[p]||siz[i]>siz[son[p]])son[p]=i;
    }
};
int cnt=0;
V<int>(n).swap(rev),V<int>(n).swap(seg),V<int>(n,-1).swap(top);
dfs1(rt,-1);
function<void(int,int)>dfs2=[&](int p,int k){
    seg[p]=cnt,rev[cnt++]=p,top[p]=k;
    if(~son[p]){
        dfs2(son[p],k);
        for(int i:to[p])
            if(!~top[i])
                dfs2(i,i);
    }
};
dfs2(rt,rt);
}
inline int lca(int x,int y)const{
    assert(0<=x),assert(x<n),assert(0<=y),assert(y<n);
    while(top[x]!=top[y]){
        if(dep[top[x]]<dep[top[y]])swap(x,y);
        x=fa[top[x]];
    }
    return dep[x]<dep[y]?x:y;
}
inline int kthac(int p,int k){
    assert(0<=p),assert(p<n),assert(k>=0),assert(k<=dep[p]);
    while(k>dep[p]-dep[top[p]]){
        k-=dep[p]-dep[top[p]]+1;
        p=fa[top[p]];
    }
    return rev[seg[p]-k];
}
inline V<pii> path(int x,int y,bool dir=0){
    assert(0<=x),assert(x<n),assert(0<=y),assert(y<n);
    V<pii>ret,ter;
    bool rv=0;
    while(top[x]!=top[y]){
        if(dep[top[x]]<dep[top[y]])rv^=1,swap(x,y);
        if(dir){
            if(rv)ter.eb(seg[top[x]],seg[x]);
            else ret.eb(seg[x],seg[top[x]]);
        }
        else (rv?ter:ret).eb(seg[top[x]],seg[x]);
        x=fa[top[x]];
    }
    if(dep[x]>dep[y])rv^=1,swap(x,y);
    if(dir){
        if(rv)ter.eb(seg[y],seg[x]);
        else ret.eb(seg[x],seg[y]);
    }
    else (rv?ret:ter).eb(seg[x],seg[y]);
    reverse(ALL(ter));
    ret.insert(ret.end(),ALL(ter));
}

```

```

        return ret;
    }
};

inline void virt_tree(V<int> &p, const tree_chain &tc, V<V<int>> &to){
    sort(ALL(p), [&](int x, int y){return tc.seg[x]<tc.seg[y];});
    p.erase(unique(ALL(p)), p.end());
    auto add_edge=[&](int x, int y){to[x].pb(y), to[y].pb(x);};
    V<int>st;
    for(int i:p){
        if(st.size()){
            int anc=tc.lca(i, st.back());
            if(anc!=st.back()){
                while(st.size()>1&&tc.seg[anc]<tc.seg[st[st.size()-2]])add_edge(st,
                    ↪ [st.size()-2], st.back()), st.qb();
                if(st.size()==1||tc.seg[anc]>tc.seg[st[st.size()-2]])V<int>().swap
                    ↪ (to[anc]), add_edge(anc, st.back()), st.back()=anc;
                else add_edge(anc, st.back()), st.qb();
            }
        }
        V<int>().swap(to[i]), st.pb(i);
    }
    while(st.size()>1)add_edge(st[st.size()-2], st.back()), st.qb();
}

// root: n-1
inline V<int> pru2fa(const V<int> &p){
    int n=p.size()+2;
    V<int>deg(n), p=p; p.pb(n-1);
    for(int i:_p)++deg[i];
    V<int>fa(n-1);
    int j=0;
    For(i, n-1){
        while(deg[j])++j;
        fa[j]=p[i];
        while(i<n-1&&!--deg[p[i]]&&p[i]<j){
            if(i+1<n-1)fa[p[i]]=p[i+1];
            ++i;
        }
        ++j;
    }
    return fa;
}

inline V<V<int>> pru2tr(const V<int> &p){
    int n=p.size()+2;
    V<int>fa=pru2fa(p);
    V<V<int>>to(n);
    For(i, n-1)to[i].pb(fa[i]), to[fa[i]].pb(i);
    return to;
}

inline V<int> fa2pru(const V<int> &fa){
    int n=fa.size()+1;
    V<int>deg(n);
    for(int i:fa)++deg[i];
    int j=0;

```

```

V<int>p(n-2);
For(i,n-2){
    while(deg[j])++j;
    p[i]=fa[j];
    while(i<n-2&&!-deg[p[i]]&&p[i]<j){
        if(i+1<n-2)p[i+1]=fa[p[i]];
        ++i;
    }
    ++j;
}
return p;
}
inline V<int> tr2pru(const V<int>> &to){
    int n=to.size();
    V<int>fa(n-1,-1);
    queue<int>q;
    q.push(n-1);
    while(q.size()){
        int p=q.front();q.pop();
        for(int i:to[p])if(i<n-1&&!~fa[i])fa[i]=p,q.push(i);
    }
    return fa2pru(fa);
}

```

## 树状数组.hpp

```

template<class T>
struct BIT{
    // d-indexed [-d+1,n]->[1,n+d]
    V<T>c1,c2;
    int d,n;
    inline void resize(int n_,int d_=1){
        d=d_,n=n_;
        V<T>(n+d+1).swap(c1);
        V<T>(n+d+1).swap(c2);
    }
    inline BIT(int n=0,int d=1){resize(n,d);}
    inline void add(int l,int r,const T &v){
        if(l>r)return;
        l+=d,assert(0<l),assert(l<=n+d);
        for(int i=l;i<=n+d;i+=i&-i)c1[i]+=v,c2[i]+=(l-1)*v;
        r+=d,assert(0<r),assert(r<=n+d);
        for(int i=r+1;i<=n+d;i+=i&-i)c1[i]-=v,c2[i]-=r*v;
    }
    inline void add(int k,const T &v){add(k,k,v);}
    inline T query(int l,int r){
        if(l>r)return T();
        T ret=0;
        r+=d,assert(0<r),assert(r<=n+d);
        for(int i=r;i;i^=i&-i)ret+=r*c1[i]-c2[i];
        l+=d,assert(0<l),assert(l<=n+d);
        for(int i=l-1;i;i^=i&-i)ret-=(l-1)*c1[i]-c2[i];
        return ret;
    }
}

```

```

    inline T query(int k){return query(k,k);}
};

template<class T>
struct BIT3{
    // d-indexed [-d+1,n]->[1,n+d]
    V<T>c;
    int d,n;
    inline void resize(int n_,int d_=1){
        d=d_,n=n_;
        V<T>(n+d+1).swap(c);
    }
    inline BIT3(int n=0,int d=1){resize(n,d);}
    inline void add(int k,const T &v){
        k+=d;
        assert(1<=k),assert(k<=n+d);
        for(int i=k;i<=n+d;i+=i&-i)c[i]+=v;
    }
    inline T query(int k){
        k+=d;
        assert(1<=k),assert(k<=n+d);
        T ret=0;
        for(int i=k;i>0;i^=i&-i)ret+=c[i];
        return ret;
    }
};

template<class T>
struct BIT4{
    // d-indexed [-d+1,n]->[1,n+d]
    V<T>c;
    int d,n;
    inline void resize(int n_,int d_=1){
        d=d_,n=n_;
        V<T>(n+d+1).swap(c);
    }
    inline BIT4(int n=0,int d=1){resize(n,d);}
    inline void add(int k,const T &v){
        k+=d;
        assert(1<=k),assert(k<=n+d);
        for(int i=k;i>0;i^=i&-i)c[i]+=v;
    }
    inline T query(int k){
        k+=d;
        assert(1<=k),assert(k<=n+d);
        T ret=0;
        for(int i=k;i<=n+d;i+=i&-i)ret+=c[i];
        return ret;
    }
};

template<class T>
inline ll invpair(const T &a){
    ll ret=0;
    BIT4<int>t(*max_element(ALL(a))+1);

```

```

    for(const auto &i:a) ret+=t.query(i+1),t.add(i,1);
    return ret;
}

```

## 矩阵.hpp

```

template<class T>
struct matrix{
    int n,m;
    V<V<T>>>a;
    inline matrix(int _n=0,int _m=0,T v=T()):n(_n),m(_m){
        V<V<T>>>(n,V<T>(m,v)).swap(a);
    };
    inline V<T> &operator[](int idx){return a[idx];}
    inline const V<T> &operator[](int idx)const{return a[idx];}
    inline matrix operator*(const matrix &rhs){
        assert(m==rhs.n);
        matrix ret(n,rhs.m);
        For(i,n)For(j,rhs.m)For(k,m)ret[i][j]+=a[i][k]*rhs[k][j];
        return ret;
    }
    inline matrix trans(){
        matrix ret(m,n);
        For(i,n)For(j,m)ret[j][i]=a[i][j];
        return ret;
    }
    inline bool gauss(){
        assert(n<=m);
        int nw=0;
        For(i,n){
            if(!a[nw][i])FOR(j,nw+1,n)if(a[j][i]){swap(a[nw],a[j]);break;}
            if(a[nw][i]){
                For(j,n)if(nw!=j){
                    T coef=a[j][i]/a[nw][i];
                    FOR(k,i,m)a[j][k]-=coef*a[nw][k];
                }
                ++nw;
            }
        }
        return nw==n;
    }
    inline matrix unit(){
        assert(n==m);
        matrix ret(n,n);
        For(i,n)ret[i][i]=1;
        return ret;
    }
    inline matrix pow(ull k){
        matrix base=*this,ret=unit();
        for(;k>=1;base=base*base)if(k&1)ret=ret*base;
        return ret;
    }
    inline matrix mul_pow(const matrix &rhs,ull k){
        matrix base=rhs,ret=*this;

```



```

        for(;k;k>=1,base=base*base)if(k&1)ret=ret*base;
        return ret;
    }
};

template<class T>
struct dis_matrix{
    int n,m;
    V<V<T>>>a;
    inline dis_matrix(int _n=0,int _m=0,T v=T()):n(_n),m(_m){
        assert((is_same<T,int>::value)|| (is_same<T,ll>::value)|| (is_same<T,ull>::value)||
            value));
        V<V<T>>>(n,V<T>(m)).swap(a);
    };
    inline V<T> &operator[](int idx){return a[idx];}
    inline const V<T> &operator[](int idx)const{return a[idx];}
    inline dis_matrix operator*(const dis_matrix &rhs){
        assert(m==rhs.n);
        dis_matrix ret(n,rhs.m,is_same<T,int>::value?inf:infl);
        For(i,n)For(j,rhs.m)For(k,m)ckmin(ret[i][j],a[i][k]+rhs[k][j]);
        return ret;
    }
    inline dis_matrix pow(ull k){
        dis_matrix base=*this,ret(n,n,is_same<T,int>::value?inf:infl);
        for(;k;k>=1,base=base*base)if(k&1)ret=ret*base;
        return ret;
    }
};

```

## 离散化.hpp

```

template<class T>
struct disc{
    // 0-indexed
    vector<T>d;
    inline disc(){}
    inline void insert(const T &x){d.pb(x);}
    inline void insert(const V<T> &v){d.insert(d.end(),ALL(v));}
    inline void init(){sort(ALL(d));d.erase(unique(ALL(d)),d.end());}
    inline disc(const vector<T> &v){d=move(v);init();}
    inline int query(const T &x){return lower_bound(ALL(d),x)-d.begin();}
    inline int size(){return d.size();}
};

template<class T,class container>
struct genID{
    int cnt;
    container id;
    inline genID():cnt(0){}
    inline bool count(const T &ele){return id.count(ele);}
    inline int get_id(const T &ele){
        auto it=id.emplace(ele,-1);
        if(it.se)it.fi->se=cnt++;
        return it.fi->se;
    }
};

```

```

    }
};

```

## 线性基.hpp

```

template<class T,int n>
struct LB{
    V<T>d;
    int cnt,failed;
    inline void clear(){cnt=failed=0,V<T>(n).swap(d);}
    inline LB(){
        assert(n>0);
        assert(n<=(is_same<T,int>::value?31:is_same<T,unsigned>::value?32:is_same<
            ↪ <T,ll>::value?63:is_same<T,ull>::value?64:-1));
        clear();
    }
    inline bool insert(T k){
        Rep(i,n)if(k>>i&1){
            if(!d[i]){
                ++cnt,d[i]=k;
                return true;
            }
            else if(!(k^=d[i]))break;
        }
        ++failed;
        return false;
    }
    inline bool can(T k){
        Rep(i,n)if(k>>i&1){
            if(!d[i])return false;
            else if(!(k^=d[i]))break;
        }
        return true;
    }
    inline T mx(T k=0){
        Rep(i,n)ckmax(k,k^d[i]);
        return k;
    }
    inline LB operator+(const LB &rhs){
        LB ret=rhs;
        ret.failed+=failed;
        For(i,n)if(d[i])ret.insert(d[i]);
        return ret;
    }
    inline LB &operator+=(const LB &rhs){
        failed+=rhs.failed;
        For(i,n)if(rhs.d[i])insert(rhs.d[i]);
        return *this;
    }
    // assumed that empty set isn't allowed
    inline T count(){return (T(1)<<cnt)-!failed;}
    // 0-indexed
    inline T rk(T k){
        T pw2=1,ret=0;

```

```

        For(i,n)if(d[i]){
            if(k>>i&1)ret|=pw2;
            pw2<<=1;
        }
        return ret;
    }
    inline T at(T k){
        if(!failed)++k;
        FOR(i,1,n)Rep(j,i)if(d[i]>>j&1)d[i]^=d[j];
        T ret=0;
        For(i,n)if(d[i]){
            if(k&1)ret^=d[i];
            k>>=1;
        }
        return k?-1:ret;
    }
};

template<class T,int n>
struct LB_ts{ // timestamp
    V<T>d;
    V<int>t;
    inline void clear(){V<T>(n).swap(d),V<int>(n).swap(t);}
    inline LB_ts(){
        assert(n>0);
        assert(n<=(is_same<T,int>::value?31:is_same<T,unsigned>::value?32:is_same<
            ↪ <T,ll>::value?63:is_same<T,ull>::value?64:-1));
        clear();
    }
    inline bool insert(T k,int tm){
        Rep(i,n)if(k>>i&1){
            if(!d[i]){
                d[i]=k,t[i]=tm;
                return true;
            }
            else if(tm>t[i])swap(d[i],k),swap(t[i],tm);
            if(!(k^=d[i]))break;
        }
        return false;
    }
    inline bool can(T k,int tm=0){
        Rep(i,n)if(k>>i&1){
            if(!d[i]||t[i]<tm)return false;
            else if(!(k^=d[i]))break;
        }
        return true;
    }
    inline T mx(T k=0,int tm=0){
        Rep(i,n)if(t[i]>=tm)ckmax(k,k^d[i]);
        return k;
    }
    inline LB_ts operator+(const LB_ts &rhs){
        LB_ts ret=rhs;
        For(i,n)if(d[i])ret.insert(d[i],t[i]);
    }
};

```

```

        return ret;
    }
    inline LB_ts &operator+=(const LB_ts &rhs){
        For(i,n)if(rhs.d[i])insert(rhs.d[i],rhs.t[i]);
        return *this;
    }
};

```

## 线段树.hpp

```

template<class T,T e,T(*merge)(T,T)>
struct SGT{
    int n;
    V<T>t;
    inline void resize(int n_){V<T>((n=n_)<<2,e).swap(t);}
    inline SGT(int n_=0){resize(n_);}
    inline void push_up(int p){t[p]=merge(t[p<<1],t[p<<1|1]);}
    void build(int p,int l,int r,const V<T>&v){
        if(l==r){t[p]=v[l];return;}
        int mid=l+r>>1;
        build(p<<1,l,mid,v),build(p<<1|1,mid+1,r,v);
        push_up(p);
    }
    inline void build(const V<T>&v){
        assert(v.size()==n);
        build(1,0,n-1,v);
    }
    void build(int p,int l,int r){
        if(l==r){t[p]=e;return;}
        int mid=l+r>>1;
        build(p<<1,l,mid),build(p<<1|1,mid+1,r);
        push_up(p);
    }
    inline void build(){
        build(1,0,n-1);
    }
    void query(int p,int l,int r,int ql,int qr,T &ret){
        if(ql<=l&&r<=qr){ret=t[p];return;}
        int mid=l+r>>1;
        if(ql<=mid)query(p<<1,l,mid,ql,qr,ret);
        if(qr>mid)query(p<<1|1,mid+1,r,ql,qr,ret);
    }
    inline T query(int l,int r){
        assert(0<=l),assert(l<=r),assert(r<n);
        T ret=e;
        query(1,0,n-1,l,r,ret);
        return ret;
    }
    void modify(int p,int l,int r,int k,const T &v){
        if(l==r){t[p]=v;return;}
        int mid=l+r>>1;
        k<=mid?modify(p<<1,l,mid,k,v):modify(p<<1|1,mid+1,r,k,v);
        push_up(p);
    }
}

```

```

inline void modify(int k, const T& v){
    assert(0<=k), assert(k<n);
    modify(1, 0, n-1, k, v);
}

};

template<class T, T e>
struct SGTlazy{
    int n;
    V<T> t, tag;
    inline void resize(int n_){n=n_, V<T>(n<<2, e).swap(t), V<T>(n<<2, e).swap(tag);}
    inline SGTlazy(int n_=0){resize(n_);}
    inline void push_up(int p){}
    inline void add_tag(int p, const T &v){}
    inline void push_down(int
        ↪ p){add_tag(p<<1, tag[p]), add_tag(p<<1|1, tag[p]), tag[p]=e;}
    void build(int p, int l, int r, const V<T>&v){
        if(l==r){t[p]=v[l]; return;}
        int mid=l+r>>1;
        build(p<<1, l, mid, v), build(p<<1|1, mid+1, r, v);
        push_up(p);
    }
    inline void build(const V<T>&v){
        assert(v.size()==n);
        build(1, 0, n-1, v);
    }
    void query(int p, int l, int r, int ql, int qr, T &ret){
        if(ql<=l&&r<=qr){return;}
        push_down(p);
        int mid=l+r>>1;
        if(ql<=mid) query(p<<1, l, mid, ql, qr, ret);
        if(qr>mid) query(p<<1|1, mid+1, r, ql, qr, ret);
    }
    inline T query(int l, int r){
        assert(0<=l), assert(l<=r), assert(r<n);
        T ret=e;
        query(1, 0, n-1, l, r, ret);
        return ret;
    }
    void modify(int p, int l, int r, int k, const T &v){
        if(l==r){t[p]=v; return;}
        push_down(p);
        int mid=l+r>>1;
        k<=mid?modify(p<<1, l, mid, k, v):modify(p<<1|1, mid+1, r, k, v);
        push_up(p);
    }
    inline void modify(int k, const T& v){
        assert(0<=k), assert(k<n);
        modify(1, 0, n-1, k, v);
    }
    void add(int p, int l, int r, int ql, int qr, const T &v){
        if(ql<=l&&r<=qr){add_tag(p, v); return;}
        push_down(p);
        int mid=l+r>>1;

```

```

        if(ql<=mid)add(p<<1,l,mid,ql,qr,v);
        if(qr>mid)add(p<<1|1,mid+1,r,ql,qr,v);
        push_up(p);
    }
    inline void add(int l,int r,const T &v){
        assert(0<=l),assert(l<=r),assert(r<n);
        add(1,0,n-1,l,r,v);
    }
    // int find_l(int p,int l,int r,int ql,int qr,const T &v){
    //     if(l==r)return l;
    //     push_down(p);
    //     int mid=l+r>>1;
    //     if(ql>mid||)return find_l(p<<1|1,mid+1,r,ql,qr,v);
    //     return find_l(p<<1,l,mid,ql,qr,v);
    // }
    // inline int find_l(int l,int r,const T &v){
    //     assert(0<=l),assert(l<=r),assert(r<n),assert(t[1]>=v);
    //     return find_l(1,0,n-1,l,r,v);
    // }
    // int find_r(int p,int l,int r,int ql,int qr,const T &v){
    //     if(l==r)return r;
    //     push_down(p);
    //     int mid=l+r>>1;
    //     if(qr<=mid||)return find_r(p<<1,l,mid,ql,qr,v);
    //     return find_r(p<<1|1,mid+1,r,ql,qr,v);
    // }
    // inline int find_r(int l,int r,const T &v){
    //     assert(0<=l),assert(l<=r),assert(r<n),assert(t[1]>=v);
    //     return find_r(1,0,n-1,l,r,v);
    // }
};

template<class T>
struct SGT_2n{
    int n;
    V<T>t,tag;
    inline int idx(int l,int r){return l+r|l!=r;}
    #define p idx(l,r)
    #define ls idx(l,mid)
    #define rs idx(mid+1,r)
    inline void resize(int n_){n=n_,V<T>(n<<1).swap(t),V<T>(n<<1).swap(tag);}
    inline SGT_2n(int n_=0){resize(n_);}
    void build(int l,int r,const V<T>&v){
        if(l==r){t[p]=v[l];return;}
        int mid=l+r>>1;
        build(l,mid,v),build(mid+1,r,v);
        t[p]=max(t[ls],t[rs]);
    }
    inline void build(const V<T>&v){build(0,n-1,v);}
    void modify(int l,int r,int k,const T &v){
        if(l==r){t[p]=v;return;}
        int mid=l+r>>1;
        if(tag[p])t[ls]+=tag[p],t[rs]+=tag[p],tag[ls]+=tag[p],tag[rs]+=tag[p],tag_
        ↪ [p]=0;
    }
};

```

```

        k<=mid?modify(l,mid,k,v):modify(mid+1,r,k,v);
        t[p]=max(t[ls],t[rs]);
    }
    inline void modify(int k,const T& v){modify(0,n-1,k,v);}
    #undef p
    #undef ls
    #undef rs
};

```

## 网络流.hpp

```

struct maxflow{
    V<pii>e;
    V<V<int>>>hd;
    int n,S,T;
    inline void add_edge(int x,int y,int z){
        assert(0<=x),assert(x<n),assert(0<=y),assert(y<n),assert(z>=0);
        hd[x].pb(e.size()),e.eb(y,z),hd[y].pb(e.size()),e.eb(x,0);
    }
    inline maxflow(int _n=0,int _S=-1,int _T=-1){
        V<V<int>>>(n=_n).swap(hd);
        S=_S,T=_T;
    }
    inline maxflow(const V<V<pii>>> &to,int _S=-1,int _T=-1){
        V<V<int>>>(n=to.size()).swap(hd);
        For(i,n)for(const pii &j:to[i])add_edge(i,j.fi,j.se);
        S=_S,T=_T;
    }
    inline ll dinic(){
        assert(S!=-1),assert(T!=-1);
        V<int>dep;
        auto bfs=[&]() {
            V<int>(n).swap(dep);
            dep[S]=1;
            queue<int>q;
            q.push(S);
            while(q.size()){
                int p=q.front();q.pop();
                for(int i:hd[p])if(e[i].se&&!dep[e[i].fi])dep[e[i].fi]=dep[p]+1,q.
                    ↪ push(e[i].fi);
            }
            return dep[T];
        };
        function<ll(int,ll)>dfs=[&](int p,ll lim){
            if(p==T)return lim;
            ll sum=0;
            for(int i:hd[p])if(e[i].se&&dep[p]+1==dep[e[i].fi]){
                ll f=dfs(e[i].fi,min((ll)e[i].se,lim-sum));
                e[i].se-=f,e[i^1].se+=f;
                if((sum+=f)==lim)break;
            }
            if(!sum)dep[p]=0;
            return sum;
        };
    };
};

```

```

        ll ret=0;
        while(bfs())ret+=dfs(S,infl);
        return ret;
    }
};

struct mincost{
    V<array<int,3>>>e;
    V<V<int>>>hd;
    int n,S,T;
    inline void add_edge(int x,int y,int z,int w){
        assert(0<=x),assert(x<n),assert(0<=y),assert(y<n),assert(z>=0);
        hd[x].pb(e.size()),e.pb({y,z,w}),hd[y].pb(e.size()),e.pb({x,0,-w});
    }
    inline mincost(int _n=0,int _S=-1,int _T=-1){
        V<V<int>>>(n=_n).swap(hd);
        S=_S,T=_T;
    }
    inline mincost(const V<array<int,3>>> &to,int _S=-1,int _T=-1){
        V<V<int>>>(n=to.size()).swap(hd);
        For(i,n)for(const array<int,3> &j:to[i])add_edge(i,j[0],j[1],j[2]);
        S=_S,T=_T;
    }
}
typedef pair<ll,ll> pll;
inline pll primal_dual(){
    assert(S!=-1),assert(T!=-1);
    V<ll>h;
    V<bool>vis(n);
    auto spfa=[&]{
        h.assign(n,infl);
        h[S]=0;
        queue<int>q;
        q.push(S);
        while(q.size()){
            int p=q.front();q.pop();
            vis[p]=false;
            for(int i:hd[p])if(e[i][1]&&ckmin(h[e[i][0]],h[p]+e[i][2])&&!vis[e[i][0]])q.push(e[i][0]),vis[e[i][0]]=true;
        }
    };
    spfa();
    V<ll>dis;
    V<pii>pre(n);
    auto dijkstra=[&](){
        V<ll>(n,infl).swap(dis);
        dis[S]=0;
        priority_queue<pli>q;
        q.emplace(0,S);
        V<bool>vis(n);
        while(q.size()){
            int p=q.top().se;q.pop();
            if(vis[p])continue;
            vis[p]=true;

```



```

        for(int i:hd[p])if(e[i][1]&&ckmin(dis[e[i][0]],dis[p]+e[i][2]+h[p]-
        ↪ h[e[i][0]])){
            pre[e[i][0]]={p,i};
            if(!vis[e[i][0]])q.emplace(-dis[e[i][0]],e[i][0]);
        }
    }
    return dis[T]!=infl;
};
ll ret1=0,ret2=0;
while(dijkstra()){
    For(i,n)h[i]+=dis[i];
    ll f=infl;
    for(int i=T;i!=S;i=pre[i].fi)ckmin(f,(ll)e[pre[i].se][1]);
    for(int i=T;i!=S;i=pre[i].fi)e[pre[i].se][1]-=f,e[pre[i].se^1][1]+=f;
    ret1+=f,ret2+=f*h[T];
}
return {ret1,ret2};
}
inline pll dinic(){
    assert(S!=-1),assert(T!=-1);
    V<int>cur(n);
    V<ll>dis;
    V<V<int>>tmp=hd;
    V<bool>vis(n);
    auto spfa=[&]() {
        dis.assign(n,infl);
        dis[S]=0;
        hd=tmp;
        queue<int>q;
        q.push(S);
        while(q.size()){
            int p=q.front();q.pop();
            vis[p]=false;
            for(int i:hd[p])if(e[i][1]&&ckmin(dis[e[i][0]],dis[p]+e[i][2])&&!
            ↪ vis[e[i][0]])q.push(e[i][0]),vis[e[i][0]]=true;
        }
        return dis[T]<infl;
    };
};
ll ret1=0,ret2=0;
auto dfs=[&](auto &&self,int p,ll f)->ll{
    if(p==T)return f;
    vis[p]=true;
    ll ret=0;
    while(hd[p].size()){
        int i=hd[p].back();
        if(!vis[e[i][0]]&&e[i][1]&&dis[e[i][0]]==dis[p]+e[i][2]){
            ll d=self(self,e[i][0],min((ll)e[i][1],f-ret));
            if(d){
                ret+=d,ret2+=d*e[i][2];
                e[i][1]-=d,e[i^1][1]+=d;
                if(ret==f)break;
            }
        }
    }
    hd[p].qb();
}

```

```

    }
    vis[p]=false;
    return ret;
};
while(spfa()){
    ll d;
    while(d=dfs(dfs,S,infl)) ret1+=d;
}
return {ret1,ret2};
}
};

```

## 计算几何.hpp

```

const double eps=1e-8;
struct vec2D{
    double x,y;
    inline vec2D(double x_=0,double y_=0):x(x_),y(y_){}
    inline vec2D operator+(const vec2D &rhs)const{return {x+rhs.x,y+rhs.y};}
    inline vec2D operator-(const vec2D &rhs)const{return {x-rhs.x,y-rhs.y};}
    inline double cross(const vec2D &rhs){return x*rhs.y-y*rhs.x;}
    inline double operator*(const vec2D &rhs)const{return x*rhs.x+y*rhs.y;}
    // unsafe since overflow, use !cross() instead
    // inline bool coln(const vec2D &rhs){return
    ↪ (*this*rhs)*(this*rhs)==(this*this)*(rhs*rhs);}
    inline bool coln(const vec2D &rhs){return fabs(cross(rhs))<eps;}
    inline int dir(const vec2D &rhs){return !coln(rhs)?cross(rhs)>=eps?1:-1:0;}
    inline double norm(){return sqrt(x*x+y*y);}
    inline double proj(const vec2D &rhs){return 1.*(this*rhs)/(this*this);}
    inline vec2D rot(double theta){
        double c=cos(theta),s=sin(theta);
        return {x*c+y*s,y*c-x*s};
    }
    inline int quad(){
        if(x>0&&y>=0) return 1;
        if(x<=0&&y>0) return 2;
        if(x<0&&y<=0) return 3;
        if(x>=0&&y<0) return 4;
        return 0;
    }
};

struct vec2d{
    ll x,y;
    inline vec2d(ll x_=0,ll y_=0):x(x_),y(y_){}
    inline vec2d operator+(const vec2d &rhs)const{return {x+rhs.x,y+rhs.y};}
    inline vec2d operator-(const vec2d &rhs)const{return {x-rhs.x,y-rhs.y};}
    inline ll cross(const vec2d &rhs){return x*rhs.y-y*rhs.x;}
    inline ll operator*(const vec2d &rhs)const{return x*rhs.x+y*rhs.y;}
    // unsafe since overflow, use !cross() instead
    // inline bool coln(const vec2d &rhs){return
    ↪ (*this*rhs)*(this*rhs)==(this*this)*(rhs*rhs);}
    inline bool coln(const vec2d &rhs){return !cross(rhs);}
    inline int dir(const vec2d &rhs){return cross(rhs)?cross(rhs)>0?1:-1:0;}
};

```

```

inline double norm(){return sqrt(x*x+y*y);}
inline double proj(const vec2d &rhs){return 1.*(*this*rhs)/(*this**this);}
inline vec2D rot(double theta){
    double c=cos(theta),s=sin(theta);
    return {x*c+y*s,y*c-x*s};
}
inline int quad(){
    if(x>0&&y>=0)return 1;
    if(x<=0&&y>0)return 2;
    if(x<0&&y<=0)return 3;
    if(x>=0&&y<0)return 4;
    return 0;
}
};

```