Contents

Template

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

#define ff first
#define ss second
#define mp make_pair
#define pb push_back
#define eb emplace_back
#define MOD 1000000009LL

using namespace std;

typedef long long ll;

const ll oo = 1000000000000000000;
const int N = 100005;
```

Ad hoc

Go up for ultras

```
struct Segtree{
   int n;
   vector<int> st;

   void build(int p, int L, int R, const int v[]){
      if(L == R){ st[p] = v[L]; return; }
      int mid = (L + R) / 2;
      build(2*p, L, mid, v);
      build(2*p+1, mid+1, R, v);
      st[p] = max(st[2*p], st[2*p+1]);
   }
   int findL(int p, int i, int L, int R, int v){
      if(i <= L || v >= st[p]) return -1;
      if(L == R) return L;

      int mid = (L + R) / 2;
      int ret = -1;
      if(i > mid+1 && st[2*p+1] > v)
         ret = findL(2*p+1, i, mid+1, R, v);
      if(ret != -1) return ret;
      return findL(2*p, i, L, mid, v);
   }

   int findR(int p, int i, int L, int R, int v){
      if(i > R || v >= st[p]) return -1;
      if(L == R) return L;
      int mid = (L + R) / 2;
      int ret = -1;
      if(i < mid && st[2*p] > v)
         ret = findR(2*p, i, L, mid, v);
      if(ret != -1) return ret;
      return findR(2*p+1, i, mid+1, R, v);
   }

   public:
   Segtree(int sz, const int v[]) : n(sz), st(4*sz, 0){
      build(1, 0, n-1, v);
   }
   int findR(int i, int v){
      return findR(1, i, 0, n-1, v);
   }
   int findL(int i, int v){
      return findL(1, i, 0, n-1, v);
   }
};
```

Estrutura de Dados

Segtree

```
struct Segtree{
   int n;
   vector<ll> st, lazy;

   void prop(int p, int L, int R){
      if(lazy[p]){
         st[p] += lazy[p] * (R - L + 1);
         if(L != R) lazy[2*p] += lazy[p], lazy[2*p+1] += lazy[p];
         lazy[p] = 0;
      }
   }

   void update(int p, int L, int R, int i, int j, ll v){
      prop(p, L, R);
      if(L > j || R < i) return;
      if(L >= i && R <= j){
         lazy[p] = v;
         prop(p, L, R);
         return;
      }
      int mid = (L+R)/2;
      update(2*p, L, mid, i, j, v);
      update(2*p+1, mid+1, R, i, j, v);
      st[p] = st[2*p] + st[2*p+1];
   }
```

```
   ll query(int p, int L, int R, int i, int j){
      prop(p, L, R);
      if(L > j || R < i) return 0;
      if(L >= i && R <= j) return st[p];
      int mid = (L+R)/2;
      return query(2*p, L, mid, i, j) + query(2*p+1, mid+1, R, i, j);
   }
public:
   Segtree(int sz = 0) : n(sz), st(4*sz, 0), lazy(4*sz, 0){}

   // sum v to every element in range [i, j]
   void update(int i, int j, ll v){
      update(1, 1, n, i, j, v);
   }
   ll query(int i, int j){
      return query(1, 1, n, i, j);
   }
};
```

Contra Ataque Ramsay

```
#include <iostream>
#include <cstdio>
#include <cstring>
#include <list>
#include <vector>

#define LADO 800
#define SEG_LADO 1400000

using namespace std;

class Sgtree{
      private:
            int arv[SEG_LADO];
      public:
            int query(int L, int R, int D, int U, int l, int r, int d, int u, int p);
            void update(int L, int R, int D, int U, int pos_x, int pos_y, int num, int p);
            Sgtree(){memset(arv, 0, SEG_LADO<<2);};
}tipo_segtree;


typedef struct _sold{
      int x,y;
      bool pai;
}tipo_soldado;


int Sgtree::query(int L, int R, int D, int U, int l, int r, int d, int u, int p) {
      if(r < L || l > R || d > U || u < D)
            return 0;
      if(L >= l && R <= r && U <= u && D >= d){
            return arv[p];
      }
      int tmp1, tmp2, tmp3, tmp4;
      tmp1 = query(L, (L+R)>>1, D, (U+D)>>1, l, r, d, u, (p<<2)+1);
      tmp2 = query(L, (L+R)>>1, ((U+D)>>1) + 1, U, l, r, d, u, (p<<2)+2);
      tmp3 = query(((L+R)>>1) + 1, R, D, (U+D)>>1, l, r, d, u, (p<<2)+3);
      tmp4 = query(((L+R)>>1) + 1, R, ((U+D)>>1) + 1, U, l, r, d, u, (p<<2)+4);

      tmp1 = max(tmp1, tmp2);
      tmp1 = max(tmp1, tmp3);
      return max(tmp1, tmp4);
}

void Sgtree::update(int L, int R, int D, int U, int pos_x, int pos_y, int num, int p){
      if(L == R && U == D){
            arv[p] = num;
      }
      else{
            if(pos_x <= (L+R)>>1){
                  if(pos_y <= (U+D)>>1)
                        update(L, (L+R)>>1, D, (U+D)>>1, pos_x, pos_y, num, (p<<2)+1);
                  else
                        update(L, (L+R)>>1, ((U+D)>>1) + 1, U, pos_x, pos_y, num, (p<<2
            }
            else{
                  if(pos_y <= (U+D)>>1)
                        update(((L+R)>>1) + 1, R, D, (U+D)>>1, pos_x, pos_y, num, (p<<2
                  else
                        update(((L+R)>>1) + 1, R, ((U+D)>>1) + 1, U, pos_x, pos_y, num,
            }
            int tmp1, tmp2;
            tmp1 = max(arv[(p<<2)+1], arv[(p<<2)+2]);
            tmp2 = max(arv[(p<<2)+3], arv[(p<<2)+4]);
            arv[p] = max(tmp1, tmp2);
      }
}

int p);
vector<int> G[50001];
Sgtree *tree;
tipo_soldado soldado[50001];
bool is_root[50001];
int ans = 1;
void dfs(int no){
      int tmp = tree->query(0, LADO, 0, LADO, 0 ,soldado[no].x-1, 0, soldado[no].y-1, 0
      tmp++;
      tree->update(0, LADO, 0, LADO, soldado[no].x, soldado[no].y, tmp, 0);

      ans = max(ans, tmp);
      for(int j : G[no])
            dfs(j);
```

```
      tree->update(0, LADO, 0, LADO, soldado[no].x, soldado[no].y, 0, 0);
}


int main() {
      int N, M, i, j, no_pai, no_filho;
      tree = new Sgtree();

      scanf("%d %d", &N, &M);
      for(i = 1; i <= N; i++){
            scanf("%d", &soldado[i].x);
            scanf("%d", &soldado[i].y);
            soldado[i].x += 400;
            soldado[i].y += 400;
      }

      for(i = 1; i <= N; i++) is_root[i] = 1;
      for(i = 1; i <= M; i++){
            scanf("%d %d", &no_filho, &no_pai);
            G[no_pai].push_back(no_filho);
            is_root[no_filho] = 0;
      }

      for(i = 1; i <= N; i++){
            if(!is_root[i]) continue;
            if(!G[i].empty())
                  dfs(i);
      }

      printf("%d\n", ans);
      return 0;
}
```

Sparse Table

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

#define mp make_pair
#define ff first
#define ss second

using namespace std;

typedef long long ll;

int st1[200005][20], st2[200005][20];

void build(int n){
   int i,j;
   for(j = 1; 1<<j <= n; j++){
      for(i = 0; i +(1<<j) <= n; i++){
         st1[i][j] = max(st1[i][j-1],st1[i+(1<<(j-1))][j-1]);
         st2[i][j] = min(st2[i][j-1],st2[i+(1<<(j-1))][j-1]);
      }
   }
}

int getA(int l, int r){
   int num = r-l+1,k=0;
   while(num>=2) num/=2, k++;
   return max(st1[l][k], st1[r-(1<<k)+1][k]);
}

int getB(int l, int r){
   int num = r-l+1,k=0;
   while(num>=2) num/=2, k++;
   return min(st2[l][k], st2[r-(1<<k)+1][k]);
}

int bsearch1(int i, int n){
   int mid,l=i-1,r=n;
   while(l+1 < r){
      mid = (l+r)>>1;
      int a = getA(i, mid);
      int b = getB(i, mid);
      if(a < b) l = mid;
      else r = mid;
   }
   return r;
}

int bsearch2(int i, int n){
   int mid,l=i-1,r=n;
   while(l+1 < r){
      mid = (l+r)>>1;
      int a = getA(i, mid);
      int b = getB(i, mid);
      if(a <= b) l = mid;
      else r = mid;
   }
   return r;
}

int main(){
   int n,i,j;

   scanf("%d", &n);
   for(i = 0; i < n; i++) scanf("%d", &st1[i][0]);
   for(i = 0; i < n; i++) scanf("%d", &st2[i][0]);
   build(n);
   ll ans = 0;
   for(i = 0; i < n; i++){
      int x = bsearch1(i,n);
```

```
      int y = bsearch2(i,n);
      if(y > x)
         ans += (y-x);
   }
   printf("%lld\n", ans);

   return 0;
}
```

Merge Sort Tree

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

using namespace std;

struct MergeTree{
   int n;
   vector<vector<int> > st;

   void build(int p, int L, int R, const int v[]){
      if(L == R){
         st[p].push_back(v[L]);
         return;
      }
      int mid = (L+R)/2;
      build(2*p, L, mid, v);
      build(2*p+1, mid+1, R, v);
      st[p].resize(R-L+1);
      merge(st[2*p].begin(), st[2*p].end(),
            st[2*p+1].begin(), st[2*p+1].end(),
            st[p].begin());
   }

   int query(int p, int L, int R, int i, int j, int x) const{
      if(L > j || R < i) return 0;
      if(L >= i && R <= j){
         int id = lower_bound(st[p].begin(), st[p].end(), x) - st[p].begin();
         return int(st[p].size()) - id;
      }
      int mid = (L+R)/2;
      return query(2*p, L, mid, i, j, x) +
         query(2*p+1, mid+1, R, i, j, x);
   }

   public:
   MergeTree(int sz, const int v[]): n(sz), st(4*sz){
      build(1, 1, n, v);
   }

   //number of elements >= x on segment [i, j]
   int query(int i, int j, int x) const{
      if(i > j) swap(i, j);
      return query(1, 1, n, i, j, x);
   }
};

int n, v[100005];

int main(){

   scanf("%d", &n);

   for(int i = 1; i <= n; i++)
      scanf("%d", v+i);

   MergeTree mst(n, v);

   return 0;
}
```

Bit bolada

```
/* bit normal -> cumulative frequency */
class ft_normal {
public:

   vector<int> ft;
   int n;

   ft_normal (int size) : n(size), ft(n, 0){}
   int query_cf(int a) const{ int resp = 0;
      for (int i = a; i; i -= (i & -i)) resp += ft[i];
      return resp; }
   int update_cf (int a, int v) {
      for (int i = a; i < n; i += (i & -i)) ft[i] += v;
      return 0; }

};


class ft_invert {
public:

   vector<int> ft_inv;
   int n;

   ft_invert (int size) : n(size), ft_inv(n, 0){}
   int query_cf_inv(int a) const{ int resp = 0;
      for (int i = a; i < n; i += (i & -i)) resp += ft_inv[i];
      return resp; }
   int update_cf_inv (int a, int v) {
      for (int i = a; i; i -= (i & -i)) ft_inv[i] += v;
```

```
      return 0; }
};

/* bit diferente -> range minimum query*/

class ft_diff {
public:
   int n;
   vector<int> ft;
   vector<int> ft_inv;
   vector<int> vet;

   ft_diff(int size) : n(size), ft(n, 0), ft_inv(n, 0), vet(n, 0){
      for (int i = 1; i < n; i++) ft[i] = ft_inv[i] = i; }
   int query_rmq (int a, int b) const{
      int i, mini = a;
      //bit normal
      for (i = a; i <= b; i += (i & -i))
         if (i + (i & -i) <= b)
            mini = vet[mini] < vet[ft_inv[i]] ? mini : ft_inv[i];
         else mini = vet[mini] < vet[i] ? mini : i;
      //bit invertida
      for (i = b; i >= a; i -= (i & -i))
         if (i - (i & -i) >= a)
            mini = vet[mini] < vet[ft[i]] ? mini : ft[i];
      return mini;
   }

   int upd (int a, int v) {
      put_value(a, v);
      update_rmq(a, v);
      return 0;
   }

   int put_value (int a, int v) {
      vet[a] = v;
      return 0;
   }
   int update_rmq (int a, int v) const{
      int mini_l = a, mini_r = a;
      for (int i = a; i < n; i += (i & -i)) {
         if (ft[i] != a) ft[i] = v < vet[ft[i]] ? a : ft[i];
         else {
            ft[i] = vet[mini_l] < vet[mini_r] ?
               (vet[mini_l] < v ? mini_l : a) : (vet[mini_r] < v ? mini_r : a);
            if (i >= a + 1)
               mini_r = vet[mini_r] < vet[ft_inv[i]] ? mini_r : i;
            if (i - (i & -i) + 1 <= a - 1)
               mini_l = vet[mini_l] < vet[ft[i - (i & -i) + 1]] ?
                  mini_l : i - (i & -i) + 1;
         }
      }
      mini_l = a, mini_r = a;
      //bit invertida
      for (int i = a; i; i -= (i & -i)) {
         if (ft_inv[i] != a) ft_inv[i] = v < vet[ft_inv[i]] ? a : ft_inv[i];
         else {
            ft_inv[i] = vet[mini_l] < vet[mini_r] ?
               (vet[mini_l] < v ? mini_l : a) : (vet[mini_r] < v ? mini_r : a);
            if (i + (i & -i) - 1 >= a + 1)
               mini_r = vet[mini_r] < vet[ft_inv[i + (i & -i) - 1]] ?
                  mini_r : (i + (i & -i) - 1);
            if (i <= a - 1)
               mini_l = vet[mini_l] < vet[ft[i]] ? mini_l : i;
         }
      }
      return 0;
   }

};
```

Paradigmas

FFT

```
// typedef complex<double> base;
struct base{
      double r, i;
      base(double r = 0, double i = 0) : r(r), i(i) {}
      base operator*(const base &o){
            return base(r*o.r - i*o.i, r*o.i + o.r*i);
      }

      base& operator*=(const base &o){
            double newr = r*o.r - i*o.i, newi = r*o.i + o.r*i;
            r = newr, i = newi;
            return *this;
      }

      base& operator+=(const base &o){
            r += o.r, i += o.i;
            return *this;
      }

      base& operator/=(const double &o){
            r /= o, i /= o;
            return *this;
      }

      base& operator-=(const base &o){
            r -= o.r, i -= o.i;
```

```
		return *this;
	}

	base operator+(const base &o){
		return base(r + o.r, i + o.i);
	}

	base operator-(const base &o){
		return base(r - o.r, i - o.i);
	}
};

double PI = acos(-1);

void fft(vector<base> &a, bool inv){
	int n = (int)a.size();

	for(int i = 1, j = 0; i < n; i++){
		int bit = n >> 1;
		for(; j >= bit; bit >>= 1)
			j -= bit;
		j += bit;
		if(i < j)
			swap(a[i], a[j]);
	}

	for(int len = 2; len <= n; len <<= 1) {
		double ang = 2*PI/len * (inv ? -1 : 1);
		base wlen(cos(ang), sin(ang));
		for(int i = 0; i < n; i += len){
			base w(1);
			for (int j = 0; j < len/2; j++){
				base u = a[i+j], v = a[i+j+len/2] * w;
				a[i+j] = u + v;
				a[i+j+len/2] = u - v;
				w *= wlen;
			}
		}
	}
	if(inv)
		for(int i = 0; i < n; i++)
			a[i] /= n;
}
void multiply(const vector<int> &a, const vector<int> &b, vector<int> &res){
	vector<base> fa(a.begin(), a.end()), fb(b.begin(), b.end());
	size_t n = 1;
	while(n < a.size()) n <<= 1;
	while(n < b.size()) n <<= 1;
	n <<= 1;
	fa.resize(n), fb.resize(n);

	fft(fa, false), fft (fb, false);
	for(size_t i = 0; i < n; i++)
		fa[i] *= fb[i];
	fft(fa, true);

	res.resize (n);
	for(size_t i = 0; i < n; ++i)
		res[i] = int(fa[i].real() + 0.5);
}
```

NTT

```
const int mod = 7340033;
const int root = 5;
const int root_1 = 4404020;
const int root_pw = 1<<20;

void fft (vector<int> & a, bool invert) {
	int n = (int) a.size();

	for (int i=1, j=0; i<n; ++i) {
		int bit = n >> 1;
		for (; j>=bit; bit>>=1)
			j -= bit;
		j += bit;
		if (i < j)
			swap (a[i], a[j]);
	}

	for (int len=2; len<=n; len<<=1) {
		int wlen = invert ? root_1 : root;
		for (int i=len; i<root_pw; i<<=1)
			wlen = int (wlen * 1ll * wlen % mod);
		for (int i=0; i<n; i+=len) {
			int w = 1;
			for (int j=0; j<len/2; ++j) {
				int u = a[i+j], v = int (a[i+j+len/2] * 1ll * w % mod);
				a[i+j] = u+v < mod ? u+v : u+v-mod;
				a[i+j+len/2] = u-v >= 0 ? u-v : u-v+mod;
				w = int (w * 1ll * wlen % mod);
			}
		}
	}
	if (invert) {
		int nrev = reverse (n, mod);
		for (int i=0; i<n; ++i)
			a[i] = int (a[i] * 1ll * nrev % mod);
	}
}
```

Matemática

Euclides Extendido

```
// a*x + b*y = gcd(a, b), <gcd, <x, y>>
typedef tuple<int, int, int> tiii;
tiii euclidesExt(int a, int b) {
      if(b == 0) return tiii(a, 1, 0);
      tiii ret = euclidesExt(b, a % b);

      int q, w, e;
      tie(q, w, e) = ret;

      get<1>(ret) = e;
      get<2>(ret) = w - e*(a / b);

      return ret;
}

// a*b = 1 (mod c) <-> a*b + c*k = 1
int invmult(int a, int b){
      return (get<1>(euclidesExt(a, b)) + b) % b;
}
```

Função totiente

```
ll totiente(ll n){
      ll ans = n;
      for(ll i = 2; i*i <= n; i++){
            if(n % i == 0){
                  ans = (ans / i) * (i-1);
                  while(n % i == 0) n /= i;
            }
      }

      if(n > 1) ans = (ans / n) * (n - 1);

      return ans;
}
```

Eliminação Gaussiana

```
// Gaussian elimination
//
// Solves systems of linear equations.
//
// To use, build a matrix of coefficients and call run(mat, R, C).
// If the i-th variable is free, row[i] will be -1, otherwise it's value will
// be ans[i].
//
// Time complexity: O(R * C^2)
//
// Constants to configure:
// - MAXC is the number of columns
// - eps is the epsilon value

namespace Gauss {
 const int MAXC = 1001;

 int row[MAXC];
 double ans[MAXC];

 void run(double mat[][MAXC], int R, int C) {
  REP(i, C) row[i] = -1;

  int r = 0;
  REP(c, C) {
   int k = r;
   FOR(i, r, R) if (fabs(mat[i][c]) > fabs(mat[k][c])) k = i;
   if (fabs(mat[k][c]) < eps) continue;

   REP(j, C+1) swap(mat[r][j], mat[k][j]);
   REP(i, R) if (i != r) {
    double w = mat[i][c] / mat[r][c];
    REP(j, C+1) mat[i][j] -= mat[r][j] * w;
   }
   row[c] = r++;
  }

  REP(i, C) {
   int r = row[i];
   ans[i] = r == -1 ? 0 : mat[r][C] / mat[r][i];
  }
 }
}
```

Grafos

LCA

```
int p[N], L[N], vis[N], dp[N][MAXL], pw[N], dp2[N][MAXL];
vector<vector<ii> > g;

void dfs(int u){
      vis[u] = 1;

      for(ii &v : g[u]){
```

```
            if(!vis[v.ff]){
                  p[v.ff] = u;
                  L[v.ff] = L[u]+1;
                  pw[v.ff] = v.ss;
                  dfs(v.ff);
            }
      }
}

int f(int u, int j){
      if(j == 0) return p[u];
      if(dp[u][j] != -1) return dp[u][j];
      return dp[u][j] = f(f(u, j-1), j-1);
}

ll h(int u, int j){
      if(j == 0) return pw[u];
      if(dp2[u][j] != -1) return dp2[u][j];
      return dp2[u][j] = h(u, j-1) + h(f(u, j-1), j-1);
}

int LCA(int u, int v){
      if(L[u] < L[v]) swap(u, v);

      for(int i = MAXL-1; i >= 0; i--)
            if(L[u] - (1 << i) >= L[v])
                  u = f(u, i);

      if(u == v) return v;

      for(int i = MAXL-1; i >= 0; i--)
            if(L[u] - (1 << i) && f(u, i) != f(v, i))
                  u = f(u, i), v = f(v, i);

      return p[u];
}

long long DIST(int u, int v){
      if(L[u] < L[v]) swap(u, v);

      ll ans = 0;

      for(int i = MAXL-1; i >= 0; i--)
            if(L[u] - (1 << i) >= L[v])
                  ans += h(u, i), u = f(u, i);

      if(u == v) return ans;

      for(int i = MAXL-1; i >= 0; i--)
            if(L[u] > (1 << i) && f(u, i) != f(v, i))
                  ans += h(u, i) + h(v, i), u = f(u, i), v = f(v, i);

      ans += pw[u] + pw[v];
      return ans;
}

int KTH(int a, int b, int c){
      int lca = LCA(a, b);
      int u = a, v = b;
      if(c > L[a] - L[lca] + 1){
            c -= L[a] - L[lca] + 1;
            for(int i = MAXL-1; i >= 0; i--)
                  if(L[v] - (1 << i) - L[lca] >= c)
                        v = f(v, i);
            return v;
      }
      else{
            for(int i = MAXL-1; i >= 0; i--)
                  if(L[a] - (L[u] - (1 << i)) + 1 <= c)
                        u = f(u, i);
            return u;

      }
      return 0;
}
```

Fluxo Máximo

The Cool Monkeys

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

using namespace std;

#define ff first
#define ss second
#define pb push_back
#define mp make_pair

const int oo = 1000000000;

typedef pair<int,int> ii;

vector<vector<int> > g;

int m, na, nb, t, source, target, ha[505], hb[505];
int mat[2020][2020], p[2020], vis[2020];

int back(int u, int minEdge){
      if(u == source) return minEdge;
      int f = back(p[u], min(minEdge, mat[ p[u] ][u]));
      mat[ p[u] ][u] -= f;
      mat[u][ p[u] ] += f;
```

```
	return f;
}

int maxflow(){
	int mf = 0, f = 1;
	while(f){
		queue<int> q;
		q.push(source);
		memset(vis, 0, sizeof vis);

		vis[source] = 1;
		p[source] = source;

		while(!q.empty()){
			int u = q.front(); q.pop();

			if(u == target) break;

			for(int i = 0; i < g[u].size(); i++){
				int v = g[u][i];
				if(mat[u][v] > 0 && vis[v] != 1){
					vis[v] = 1;
					p[v] = u;
					q.push(v);
				}
			}
		}

		if(vis[target] != 1) break;
		f = back(target, oo);
		mf += f;

	}
	return mf;
}

int buildRun(int *ha, int na, int *hb, int nb){
	g.assign(2020, vector<int>());
	sort(ha, ha+na, greater<int>());
	sort(hb, hb+nb);

	memset(mat, 0, sizeof mat);

	int cnt = 0;
	for(int i = 0; i < na; i++){
		for(int j = 0; j < nb; j++){
			int vin = i;
			int uin = na+j;
			int vout = na+nb+i;
			int uout = na+nb+na+j;
			if(abs(ha[i] - hb[j]) < t){
				// vout -> uin
				// uout -> vin
				// printf("%d -> %d\n", i, j);
				g[vout].pb(uin);
				g[uin].pb(vout);
				g[uout].pb(vin);
				g[vin].pb(uout);
				mat[vout][uin] = oo;
				mat[uout][vin] = oo;
			}
		}
	}

	for(int i = 0; i < na; i++){
		int vin = i;
		int vout = na+nb+i;
		g[vin].pb(vout);
		g[vout].pb(vin);
		mat[vin][vout] = 1;
	}


	for(int j = 0; j < nb; j++){
		int uin = na+j;
		int uout = na+nb+na+j;
		g[uin].pb(uout);
		g[uout].pb(uin);
		mat[uin][uout] = 1;
	}

	for(int i = 0; i < m; i++){
		int vin = i;
		int uout = na+nb+na+i;
		g[source].pb(vin);
		g[vin].pb(source);
		mat[source][vin] = 1;

		g[uout].pb(target);
		g[target].pb(uout);
		mat[uout][target] = 1;
	}

	return maxflow();
}

int main(){
	source = 2018;
	target = 2019;

	scanf("%d␣%d␣%d␣%d", &m, &na, &nb, &t);

	for(int i = 0; i < na; i++)
		scanf("%d", ha+i);
```

```
      for(int i = 0; i < nb; i++)
            scanf("%d", hb+i);

      if(buildRun(ha, na, hb, nb) == m ||
        buildRun(hb, nb, ha, na) == m) printf("S\n");
      else printf("N\n");

      return 0;
}
```

Batalha Naval

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

using namespace std;

int pX[200200], pY[200200], distX[200200], distY[200200];
int n, ptrx = 1, ptry = 100100;

vector<vector<int> > g(200200);

bool bfs(){
   bool found = false;
   queue<int> Q;

   for(int i = 1; i < ptrx; i++)
      if(pX[i] == -1)
         Q.push(i);

   memset(distX, 0, sizeof distX);
   memset(distY, 0, sizeof distY);

   while(!Q.empty()){
      int u = Q.front(); Q.pop();
      for(int i = 0; i < (int)g[u].size(); i++){
         int v = g[u][i];
         if(distY[v] == 0){
            distY[v] = distX[u]+1;
            if(pY[v] == -1) found = true;
            else{
               distX[ pY[v] ] = distY[v]+1;
               Q.push(pY[v]);
            }
         }
      }
   }
   return found;
}

bool dfs(int u){
   for(int i = 0; i < (int)g[u].size(); i++){
      int v = g[u][i];
      if(distX[u]+1 == distY[v]){
         distY[v] = 0; // "apaga" o vertice para a dfs
         if(pY[v] == -1 || dfs(pY[v])){
            pX[u] = v, pY[v] = u;
            return true;
         }
      }
   }
   return false;
}

int f(){
   int ans = 0;
   memset(pX, -1, sizeof pX);
   memset(pY, -1, sizeof pY);

   while(bfs())
      for(int i = 1; i < ptrx; i++)
         if(pX[i] == -1 && dfs(i)) // eh possivel escolher um par para i
            ans++;

   return ans;
}

int main(){
   int x, y;

   map<int, int> mapx;
   map<int, int> mapy;

   while(scanf("%d", &n) == 1){
      g.assign(200200, vector<int>());

      for(int i = 0; i < n; i++){
         scanf("%d %d", &x, &y);

         if(mapx.find(x) == mapx.end()) mapx[x] = ptrx++;
         if(mapy.find(y) == mapy.end()) mapy[y] = ptry++;

         x = mapx[x];
         y = mapy[y];

         g[x].push_back(y);
         g[y].push_back(x);
      }

      printf("%d\n", f());
   }
   return 0;
}
```

Circulation

```
// Circulation
//
// Given a directed weighted graph, computes the minimum cost to run the maximum
// amount of circulation flow through the graph.
//
// Configure: MAXV
// Configure: MAXE (at least 2 * calls_to_edge)
//
// Functions:
// - init(n) initializes the algorithm with the given number of nodes
// - edge(x, y, c, w) adds an edge x->y with capacity c and weight w
// - run() runs the algorithm and returns total cost
//
// Time complexity: No idea, but it should be fast enough to solve any problem
// where V and E are up to around 1000.
//
// Constants to configure:
// - MAXV is the maximum number of vertices
// - MAXE is the maximum number of edges (i.e. twice the calls to function edge)

namespace Circu {
  const int MAXV = 1000100;
  const int MAXE = 1000100;

  int V, E;
  int how[MAXV], good[MAXV], bio[MAXV], cookie = 1; llint dist[MAXV];
  int from[MAXE], to[MAXE]; llint cap[MAXE], cost[MAXE];

  void init(int n) { V = n; E = 0; }

  void edge(int x, int y, llint c, llint w) {
    from[E] = x; to[E] = y; cap[E] = c; cost[E] = +w; ++E;
    from[E] = y; to[E] = x; cap[E] = 0; cost[E] = -w; ++E;
  }

  void reset() {
    REP(i, V) dist[i] = 0;
    REP(i, V) how[i] = -1;
  }

  bool relax() {
    bool ret = false;
    REP(e, E) if (cap[e]) {
      int x = from[e];
      int y = to[e];

      if (dist[x] + cost[e] < dist[y]) {
        dist[y] = dist[x] + cost[e];
        how[y] = e;
        ret = true;
      }
    }
    return ret;
  }

  llint cycle(int s, bool flip = false) {
    int x = s;
    llint c = cap[how[x]];
    do {
      int e = how[x];
      c = min(c, cap[e]);
      x = from[e];
    } while (x != s);

    llint sum = 0;
    do {
      int e = how[x];
      if (flip) {
        cap[e] -= c;
        cap[e^1] += c;
      }
      sum += cost[e] * c;
      x = from[e];
    } while (x != s);
    return sum;
  }

  llint push(int x) {
    for (++cookie; bio[x] != cookie; x = from[how[x]]) {
      if (!good[x] || how[x] == -1 || cap[how[x]] == 0) return 0;
      bio[x] = cookie;
      good[x] = false;
    }
    return cycle(x) >= 0 ? 0 : cycle(x, true);
  }

  llint run() {
    reset();
    llint ret = 0;
    REP(step, 2*V) {
      if (step == V) reset();
      if (!relax()) continue;

      REP(i, V) good[i] = true;
      REP(i, V) if (llint w = push(i)) ret += w, step = 0;
    }
    return ret;
  }
}
```

Dinic

```
vector<pair<int, pair<ll, int> > > g[N]; // <vx, <edge weight, id reverse edge>>

int lvl[N], vis[N], source, target;

size_t px[N];

ll run(int s, ll minE){
      if(s == target) return minE;

      ll ans = 0;

      for(; px[s] < g[s].size(); px[s]++){
            auto &v = g[s][ px[s] ];
            if(lvl[v.ff] != lvl[s]+1 || !v.ss.ff) continue;
            ll tmp = run(v.ff, min(minE, v.ss.ff));
            v.ss.ff -= tmp;
            g[v.ff][v.ss.ss].ss.ff += tmp;
            ans += tmp;
            minE -= tmp;
            if(minE == 0) break;
      }
      return ans;
}

int pass;
int bfs(){

      queue<int> q;
      q.push(source);
      lvl[source] = 1;
      vis[source] = ++pass;

      while(!q.empty()){
            int u = q.front(); q.pop();
            px[u] = 0;

            for(auto v : g[u]){
                  if(v.ss.ff <= 0 || vis[v.ff] == pass) continue;
                  vis[v.ff] = pass;
                  lvl[v.ff] = lvl[u]+1;
                  q.push(v.ff);
            }
      }

      return vis[target] == pass;
}

ll flow(){
      ll ans = 0;
      while(bfs())
            ans += run(source, oo);
      return ans;
}

void addEdge(int u, int v, ll c){
      pair<int, pair<ll, int> > a, b;
      a = {u, {0, g[u].size()}};
      b = {v, {c, g[v].size()}};
      g[u].push_back(b);
      g[v].push_back(a);
}
```

Min Cost Max Flow(code by Nson)

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

using namespace std;

const int N = 20;
const int oo= 1000000000;

class edge{
   public:
      int to, cost, cap, rev;
      edge(int to = 0, int cost = 0, int cap = 0, int rev = 0) :
         to(to), cost(cost), cap(cap), rev(rev) {}
};

vector<edge> g[2*N];
int d[2*N], p[2*N], id[2*N];
int n, source, target;

void addEdge(int from, int to, int cost, int cap){
   edge a(to, cost, cap, g[to].size());
   edge b(from, -cost, 0, g[from].size());
   g[from].push_back(a);
   g[to].push_back(b);
}

int back(int s, int minE){
   if(s == source) return minE;

   int f = back(p[s], min(minE, g[ p[s] ][ id[s] ].cap));

   g[ p[s] ][ id[s] ].cap -= f;
   g[s][ g[ p[s] ][ id[s] ].rev ].cap += f;
   return f;
}
```

```
int dijkstra(){
   for(int i = 0; i < 2*N; i++) d[i] = oo;
   d[source] = 0;
   priority_queue<pair<int, int> > pq;
   pq.push({0, source});
   while(!pq.empty()){
      int u = pq.top().second;
      int r = -pq.top().first; pq.pop();
      if(r > d[u]) continue;
      for(int i = 0; i < g[u].size(); i++){
         auto x = g[u][i];
         if(!x.cap) continue;
         int w = r + x.cost;
         int v = x.to;
         if(w < d[v]){
            id[v] = i;
            p[v] = u;
            d[v] = w;
            pq.push({-w, v});
         }
      }
   }

   return d[target] != oo;
}

pair<int, int> mincost(){ // return <min cost, max flow>
   int mf = 0, ans = 0;
   while(dijkstra()){
      int f = back(target, oo);
      mf += f;
      ans += 1LL * f * d[target];
   }
   return {ans, mf};
}

int main(){


   scanf("%d", &n);

   source = 0, target = 2*N-1;

   for(int i = 1; i <= n; i++){
      addEdge(source, i, 0, 1);
      addEdge(i+n+1, target, 0, 1);

      for(int j = 1; j <= n; j++){
         int x;
         scanf("%d", &x);
         addEdge(i, n+j+1, x, 1);
      }
   }

   printf("%d\n", mincost().first);


   return 0;
}
```

Min Cost Max Flow

```
// Min-cost max-flow (uses Dijkstra's algorithm)
//
// Given a directed weighted graph, source, and sink, computes the minimum cost
// of the maximum flow from source to sink.
// This version uses Dijkstra's algorithm and gives good performance on all
// kinds of graphs.
//
// To use, call init(n), then add edges using edge(x, y, c, w), and finally
// call run(src, sink).
//
// Functions:
// - init(n) initializes the algorithm with the given number of nodes
// - edge(x, y, c, w) adds an edge x->y with capacity c and weight w
// - run(src, sink) runs the algorithm and returns {total_cost, total_flow}
//
// Time complexity: O(V * E^2 log E)
//
// Constants to configure:
// - MAXV is the maximum number of vertices
// - MAXE is the maximum number of edges (i.e. twice the calls to function edge)
// - oo is the "infinity" value

namespace Mcmf {
  const int MAXV = 1000100;
  const int MAXE = 1000100;
  const llint oo = 1e18;

  int V, E;
  int last[MAXV], how[MAXV]; llint dist[MAXV];
  int next[MAXE], from[MAXE], adj[MAXE]; llint cap[MAXE], cost[MAXE];

  struct cmpf {
    bool operator () (int a, int b) {
      if (dist[a] != dist[b]) return dist[a] < dist[b];
      return a < b;
    }
  };
  set<int, cmpf> S;

  void init(int n) {
    V = n;
```

```
  E = 0;
  REP(i, V) last[i] = -1;
 }

 void edge(int x, int y, llint c, llint w) {
  from[E] = x; adj[E] = y; cap[E] = c; cost[E] = +w; next[E] = last[x]; last[x] = E++;
  from[E] = y; adj[E] = x; cap[E] = 0; cost[E] = -w; next[E] = last[y]; last[y] = E++;
 }

 pair<llint, llint> run(int src, int sink) {
  llint total = 0;
  llint flow = 0;

  for (;;) {
   REP(i, V) dist[i] = oo;
   dist[src] = 0;

   for (;;) {
    bool done = true;
    REP(x, V) for (int e = last[x]; e != -1; e = next[e]) {
     if (cap[e] == 0) continue;

     int y = adj[e];
     llint val = dist[x] + cost[e];

     if (val < dist[y]) {
      dist[y] = val;
      how[y] = e;
      done = false;
     }
    }
    if (done) break;
   }

   if (dist[sink] >= oo / 2) break;

   llint aug = cap[how[sink]];
   for (int i = sink; i != src; i = from[how[i]])
    aug = min(aug, cap[how[i]]);

   for (int i = sink; i != src; i = from[how[i]]) {
    cap[how[i]] -= aug;
    cap[how[i]^1] += aug;
    total += cost[how[i]] * aug;
   }
   flow += aug;
  }
  return {total, flow};
 }
}
```

Min Cost Max Flow(DFS)

```
// Min-cost max-flow (uses DFS)
//
// Given a directed weighted graph, source, and sink, computes the minimum cost
// of the maximum flow from source to sink.
// This version uses DFS to find shortest paths and gives good performance on
// very "shallow" graphs: graphs which have very short paths between source
// and sink (e.g. at most 10 edges).
// In such cases this algorithm can be orders of magnitude faster than the
// Dijkstra version.
//
// To use, call init(n), then add edges using edge(x, y, c, w), and finally
// call run(src, sink).
//
// Functions:
// - init(n) initializes the algorithm with the given number of nodes
// - edge(x, y, c, w) adds an edge x->y with capacity c and weight w
// - run(src, sink) runs the algorithm and returns {total_cost, total_flow}
//
// Time complexity: O(V * E^3)
//
// Constants to configure:
// - MAXV is the maximum number of vertices
// - MAXE is the maximum number of edges (i.e. twice the calls to function edge)
// - oo is the "infinity" value

namespace Mcmf {
 const int MAXV = 1000100;
 const int MAXE = 1000100;
 const llint oo = 1e18;

 int V, E;
 int last[MAXV], curr[MAXV], bio[MAXV]; llint pi[MAXV];
 int next[MAXE], adj[MAXE]; llint cap[MAXE], cost[MAXE];

 void init(int n) {
  V = n;
  E = 0;
  REP(i, V) last[i] = -1;
  REP(i, V) pi[i] = 0;
 }

 void edge(int x, int y, llint c, llint w) {
  adj[E] = y; cap[E] = c; cost[E] = +w; next[E] = last[x]; last[x] = E++;
  adj[E] = x; cap[E] = 0; cost[E] = -w; next[E] = last[y]; last[y] = E++;
 }

 llint push(int x, int sink, llint flow) {
  if (x == sink) return flow;
  if (bio[x]) return 0;
```

```
    bio[x] = true;

    for (int &e = curr[x]; e != -1; e = next[e]) {
      int y = adj[e];

      if (cap[e] && pi[x] == pi[y] + cost[e])
        if (llint f = push(y, sink, min(flow, cap[e])))
          return cap[e] -= f, cap[e^1] += f, f;
    }
    return 0;
  }

  pair<llint, llint> run(int src, int sink) {
    llint total = 0;
    llint flow = 0;
    pi[src] = oo;

    for (;;) {
      REP(i, V) bio[i] = false;
      REP(i, V) curr[i] = last[i];

      while (llint f = push(src, sink, oo)) {
        total += pi[src] * f;
        flow += f;
        REP(i, V) bio[i] = false;
      }

      llint inc = oo;
      REP(x, V) if (bio[x]) {
        for (int e = last[x]; e != -1; e = next[e]) {
          int y = adj[e];
          if (cap[e] && !bio[y]) inc = min(inc, pi[y] + cost[e] - pi[x]);
        }
      }
      if (inc == oo) break;

      REP(i, V) if (bio[i]) pi[i] += inc;
    }
    return {total, flow};
  }
}
```

Centroid

Junior e Falta de Ideias

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

#define ff first
#define ss second
#define mp make_pair

using namespace std;

typedef long long ll;

vector<pair<int,int>> G[500005];
int subtree[500005], treesize, k;
bool vis[500005];
ll dist[500005], ans;

int dfs(int v, int p){
      subtree[v] = 1;
      for(pair<int,int> x : G[v])
            if(x.ff != p && !vis[x.ff]) subtree[v] += dfs(x.ff,v);
      return subtree[v];
}

int centroid(int v, int p){
      for(pair<int,int> x : G[v]){
            if(x.ff == p || vis[x.ff]) continue;
            if(subtree[x.ff]*2 > treesize) return centroid(x.ff,v);
      }
      return v;
}

void procurar_ans(int v, int p, int d_atual, ll custo){
      ans = min(ans, dist[k-d_atual] + custo);
      if(d_atual == k) return;
      for(pair<int,int> x : G[v]){
            if(!vis[x.ff] && x.ff != p)
                  procurar_ans(x.ff,v,d_atual+1,custo+x.ss);
      }
}

void atualiza_distancia(int v, int p, int d_atual, ll custo){
      dist[d_atual] = min(dist[d_atual], custo);
      if(d_atual == k) return;
      for(pair<int,int> x : G[v]){
            if(!vis[x.ff] && x.ff != p)
                  atualiza_distancia(x.ff,v,d_atual+1,custo+x.ss);
      }
}

void decomp(int v, int p){
      treesize = dfs(v,v);
      // if(treesize < k) return;
      int cent = centroid(v,v);
      vis[cent] = 1;

      for(int i = 1; i <= treesize; i++)
            dist[i] = 1e18;
```

```
	for(pair<int,int> x : G[cent]){
		if(!vis[x.ff]){
			procurar_ans(x.ff,cent,1,x.ss);
			atualiza_distancia(x.ff,cent,1,x.ss);
		}
	}

	for(pair<int,int> x : G[cent]){
		if(!vis[x.ff])
			decomp(x.ff, cent);
	}
}

int main(){
	int n,i,a,b;

	scanf("%d%d", &n,&k);
	for(i = 2; i <= n; i++){
		scanf("%d%d", &a,&b);
		G[i].push_back(mp(a,b));
		G[a].push_back(mp(i,b));
	}
	ans = 1e18;
	decomp(1,-1);

	printf("%lld\n", ans == 1e18 ? -1 : ans);

	return 0;
}
```

Strings

YATG

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

#define ff first
#define ss second
#define mp make_pair
#define oo 1000000000

using namespace std;

int n, k, mat[300005][26], ans;

int dfs(int u){
	int ret = oo;
	ans++;

	for(int i = 0; i < 26; i++){
		if(mat[u][i]){
			ret = min(ret, dfs(mat[u][i]));
		}
	}
	if(ret == oo){
		ret = 0;
		ans++;
	}
	ret++;
	if(ret > k){
		ans++;
		ret = 1;
	}
	return ret;
}

int main(){

	scanf("%d␣%d", &n, &k);

	char s[100005];

	int ptr = 1;

	for(int i = 0; i < n; i++){
		scanf("␣%s", s);
		int node = 0;
		for(int j = 0; s[j]; j++){
			int letra = s[j]-'a';
			if(!mat[node][letra])
				mat[node][letra] = ptr++;
			node = mat[node][letra];
		}
	}

	for(int i = 0; i < 26; i++)
		if(mat[0][i])
			dfs(mat[0][i]);

	ans += n;

	printf("%d\n", ans);

	return 0;
}
```

Trie ponteiro

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

using namespace std;
```

```
typedef long long ll;

struct node{
      bool is_end;
      int prefixes, words, maxsize;
      struct node* edge[26];
      //initialize()
      //addword(vertex, word)
      //countPrefixes(vertex, prefix)
      //countWords(vertex, word)

      node(){
            maxsize = 0;
            prefixes = 0;
            words = 0;
            is_end = false;
            for(int i = 0; i < 26; i++) edge[i] = NULL;
      }

      void addWord(string word, int tam){
            maxsize = max(tam, maxsize);
            if(word.empty()){
                  prefixes++;
                  words++;
            }
            else{
                  prefixes++;
                  int k = word[0] - 'a';
                  if(edge[k] == NULL){
                        node *p1 = new node();
                        p1->addWord(word.substr(1,word.size()-1), tam );
                        edge[k] = p1;
                  }
                  else
                        edge[k]->addWord(word.substr(1,word.size()-1), tam );
            }
      }

      int countWords(string word){
            if(word.empty())
                  return words;
            int k = word[0] - 'a';
            if(edge[k] == NULL)
                  return 0;
            return edge[k]->countWords(word.substr(1,word.size()-1) );
      }

      int countPrefixes(string word){
            if(word.empty())
                  return prefixes;
            int k = word[0] - 'a';
            if(edge[k] == NULL)
                  return 0;
            return edge[k]->countPrefixes(word.substr(1,word.size()-1) );
      }

      int countSize(string word){
            if(word.empty())
                  return maxsize;
            int k = word[0] - 'a';
            if(edge[k] == NULL)
                  return 0;
            return edge[k]->countSize(word.substr(1,word.size()-1) );
      }
};

int main() {
      int n,m;
      string s;

      while(scanf("%d", &n) != EOF){
            node *trie = new node();
            while(n--){
                  cin >> s;
                  trie->addWord(s, s.size());
            }
            scanf("%d", &m);
            while(m--){
                  cin >> s;
                  int x = trie->countPrefixes(s);
                  if(x == 0)
                        cout << "-1\n";
                  else
                        cout << x << "␣" << trie->countSize(s) << endl;
            }
      }


      return 0;
}
```

Trie

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

#define oo 1000000000000000000

using namespace std;

int mat[6400640][2];
int cnt[6400640][2];
```

```
int main(){
	int n, x, ptr, next = 1;
	char c;

	scanf("%d", &n);

	ptr = 0;
	for(int i = 30; i >= 0; i--){
		if(!mat[ptr][0]) mat[ptr][0] = next++;
		cnt[ptr][0]++;
		ptr = mat[ptr][0];
	}

	for(int i = 0; i < n; i++){
		scanf("␣%c␣%d", &c, &x);

		if(c == '+'){
			ptr = 0;
			for(int i = 30; i >= 0; i--){
				if((1 << i) & x){
					if(!mat[ptr][1]) mat[ptr][1] = next++;
					cnt[ptr][1]++;
					ptr = mat[ptr][1];
				}
				else{
					if(!mat[ptr][0]) mat[ptr][0] = next++;
					cnt[ptr][0]++;
					ptr = mat[ptr][0];
				}
			}
		}
		else if(c == '-'){
			ptr = 0;
			for(int i = 30; i >= 0; i--){
				if((1 << i) & x){
					cnt[ptr][1]--;
					ptr = mat[ptr][1];
				}
				else{
					cnt[ptr][0]--;
					ptr = mat[ptr][0];
				}
			}
		}
		else{
			int ans = 0;
			ptr = 0;
			for(int i = 30; i >= 0; i--){
				if((1 << i) & x){
					if(cnt[ptr][0] > 0){
						ans += (1 << i);
						ptr = mat[ptr][0];
					}
					else ptr = mat[ptr][1];
				}
				else{
					if(cnt[ptr][1] > 0){
						ans += (1 << i);
						ptr = mat[ptr][1];
					}
					else ptr = mat[ptr][0];
				}
			}
			printf("%d\n", ans);
		}
	}

	return 0;
}
```

Aho Corasick

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

#define ff first
#define ss second
#define mp make_pair

using namespace std;

typedef long long ll;

int trie[1000005][52], fn[1000005];
int ptr;
bool passou[1000005];
vector<int> final_vec;

int insert(char *str){
	int v = 0;

	for(int i = 0; str[i]; i++){
		int to = str[i] >= 'a' ? str[i]-'a'+26 : str[i]-'A';
		if(trie[v][to])
			v = trie[v][to];
		else
			v = trie[v][to] = ptr++;
	}

	return v;
}

void init_aho(){
	queue<int> Q;
```

```
	Q.push(0);

	while(!Q.empty()){
		int t = Q.front(); Q.pop();

		for(int i = 0; i < 52; i++){
			if(trie[t][i]){
				int x = trie[t][i];
				Q.push(x);

				if(t){
					fn[x] = fn[t];

					while(fn[x] && trie[fn[x]][i] == 0) fn[x] = fn[fn[x]];
					if(trie[fn[x]][i]) fn[x] = trie[fn[x]][i];
					trie[x][i] = fn[x];
				}
			}
		}
	}
}

int main(){
	int t,q;
	char s[100005], s2[1005];

	scanf("%d", &t);
	while(t--){
		scanf("␣%s", s);

		memset(trie, 0, sizeof trie);
		memset(passou, 0, sizeof passou);
		memset(fn, 0, sizeof fn);
		final_vec.clear();

		ptr = 1;

		scanf("%d", &q);

		// build trie
		while(q--){
			scanf("␣%s", s2);
			final_vec.push_back(insert(s2));
		}

		// build failures
		init_aho();

		// simulate
		int v = 0;
		for(int i = 0; s[i]; i++){
			int to = s[i] >= 'a' ? s[i]-'a'+26 : s[i]-'A';
			v = trie[v][to];
			else{
				while(v){
					v = fn[v];
					passou[v] = 1;
					if(trie[v][to]){
						v = trie[v][to];
						break;
					}
				}
			}
			passou[v] = 1;
		}

		for(int i = 0; i < final_vec.size(); i++){
			if(passou[final_vec[i]]) printf("y\n");
			else printf("n\n");
		}
	}

	return 0;
}
```

Suffix Array

```
// Suffix array
//
// Given a string s of length N, function suffix_array(s, N) computes an array
// of sorted suffixes: the i-th sorted suffix starts from index srt[i].second.
// Time complexity: O(N log^2 N)
//
// Function lcp(a, b) computes the length of longest common prefix of suffixes
// s[a..] and s[b..].
// Time complexity: O(log N)
//
// Constants to configure:
// - MAX is the maximum value of N
// - LG is ceil(log2(MAX)) + 1

const int MAX = 100100;
const int LG = 17 + 1;

int L;
pair<llint, int> srt[MAX];
llint buc[LG][MAX];

int lcp(int a, int b) {
	int ret = 0;
	for(int i = L-1; i >= 0; --i){
		int s = 1 << i;
```

```
            if (a+s <= N && b+s <= N && buc[i][a] == buc[i][b])
                  a += s, b += s, ret += s;
      }
      return ret;
}

void suffix_array(char *s, int N){
      for(i = 0; i < N; i++) buc[0][i] = s[i] + 1;

      for(L = 0; (1<<L) < 2*N; ++L){
            for(x = 0; x < N; x++) srt[x] = {buc[L][x] << 30, x};
            for (int x = (1<<L); x < N; x++) srt[x-(1<<L)].first += buc[L][x];
            sort(srt, srt+N);

            int pos = 1;
            for(x = 0; x < N; x++){
                  pos += i && srt[i-1].first < srt[i].first;
                  buc[L+1][srt[i].second] = pos;
            }
      }
}
```

Z Algorithm

```
// Z Algorithm
//
// Given a string s of length N, computes an array z, where z[i] is the length
// of longest substring starting from index i which is also a prefix of s.
// More information: http://codeforces.com/blog/entry/3107
//
// Time complexity: O(N)

void z_algorithm(char *s, int N, int *z) {
  z[0] = N;
  int L = -1, R = -1;

  FOR(i, 1, N) {
    z[i] = i >= R ? 0 : min(R-i, z[i-L]);
    while (i+z[i] < N && s[i+z[i]] == s[z[i]]) ++z[i];
    if (i+z[i] > R) L = i, R = i+z[i];
  }
}
```

Min rotation

```
// Lexicographically minimum rotation of a sequence
//
// Given a sequence s of length N, min_rotation(s, N) returns the start index
// of the lexicographically minimum rotation.
//
// Note: array s must be of length of at least 2 * N.
//
// Time complexity: O(N)

int min_rotation(int *s, int N) {
  REP(i, N) s[N+i] = s[i];

  int a = 0;
  REP(b, N) REP(i, N) {
    if (a+i == b || s[a+i] < s[b+i]) { b += max(0, i-1); break; }
    if (s[a+i] > s[b+i]) { a = b; break; }
  }
  return a;
}
```

All palindrome

```
// Finds all palindromes in a string
//
// Given a string s of length N, finds all palindromes as its substrings.
//
// After calling manacher(s, N, rad), rad[x] will be the radius of the largest
// palindrome centered at index x / 2.
// Example:
// s = b a n a n a a
// rad = 0000102010010
//
// Note: Array rad must be of length at least twice the length of the string.
// Also, "invalid" characters are denoted by -1, therefore the string must not
// contain such characters.
//
// Time complexity: O(N)
//
// Constants to configure:
// - MAX is the maximum length of the string

void manacher(char *s, int N, int *rad) {
  static char t[2*MAX];
  int m = 2*N - 1;

  REP(i, m) t[i] = -1;
  REP(i, N) t[2*i] = s[i];

  int x = 0;
  FOR(i, 1, m) {
    int &r = rad[i] = 0;
    if (i <= x+rad[x]) r = min(rad[x+x-i], x+rad[x]-i);
    while (i-r-1 >= 0 && i+r+1 < m && t[i-r-1] == t[i+r+1]) ++r;
    if (i+r >= x+rad[x]) x = i;
  }

  REP(i, m) if (i-rad[i] == 0 || i+rad[i] == m-1) ++rad[i];
```

```
  REP(i, m) rad[i] /= 2;
}
```

Geometria

Convex Hull

```
ll D(const Point& P, const Point& Q, const Point& R){
   return (P.x * Q.y + P.y * R.x + Q.x * R.y) - (R.x * Q.y + R.y * P.x + Q.x * P.y);
}

vector<Point> monotone_chain_ch(vector<Point> P){
   sort(P.begin(), P.end());

   vector<Point> L, U;

   for(auto p : P){
      while (L.size() >= 2 and D(L[L.size() - 2], L[L.size() -1], p) < 0)
         L.pop_back();

      L.push_back(p);
   }

   reverse(P.begin(), P.end());

   for(auto p : P){
      while (U.size() >= 2 and D(U[U.size() - 2], U[U.size() -1], p) < 0)
         U.pop_back();

      U.push_back(p);
   }

   L.pop_back();
   U.pop_back();

   L.reserve(L.size() + U.size());
   L.insert(L.end(), U.begin(), U.end());

   return L;
}
```

Nearest Points

```
struct pt {
      int x, y, id;
};

inline bool cmp_x (const pt & a, const pt & b) {
      return a.x < b.x || a.x == b.x && a.y < b.y;
}

inline bool cmp_y (const pt & a, const pt & b) {
      return a.y < b.y;
}

pt a[MAXN];

double mindist;
int ansa, ansb;
inline void upd_ans (const pt & a, const pt & b) {
      double dist = sqrt ((a.x-b.x)*(a.x-b.x) + (a.y-b.y)*(a.y-b.y) + .0);
      if (dist < mindist)
            mindist = dist, ansa = a.id, ansb = b.id;
}

void rec (int l, int r) {
      if (r - l <= 3) {
            for (int i=l; i<=r; ++i)
                  for (int j=i+1; j<=r; ++j)
                        upd_ans (a[i], a[j]);
            sort (a+l, a+r+1, &cmp_y);
            return;
      }

      int m = (l + r) >> 1;
      int midx = a[m].x;
      rec (l, m), rec (m+1, r);
      static pt t[MAXN];
      merge (a+l, a+m+1, a+m+1, a+r+1, t, &cmp_y);
      copy (t, t+r-l+1, a+l);

      int tsz = 0;
      for (int i=l; i<=r; ++i)
            if (abs (a[i].x - midx) < mindist) {
                  for (int j=tsz-1; j>=0 && a[i].y - t[j].y < mindist; --j)
                        upd_ans (a[i], t[j]);
                  t[tsz++] = a[i];
            }
}

sort (a, a+n, &cmp_x);
mindist = 1E20;
rec (0, n-1);
```

Determinante

```
const double EPS = 1E-9;
int n;
vector < vector<double> > a (n, vector<double> (n));
```

```
double det = 1;
for (int i=0; i<n; ++i) {
      int k = i;
      for (int j=i+1; j<n; ++j)
            if (abs (a[j][i]) > abs (a[k][i]))
                  k = j;
      if (abs (a[k][i]) < EPS) {
            det = 0;
            break;
      }
      swap (a[i], a[k]);
      if (i != k)
            det = -det;
      det *= a[i][i];
      for (int j=i+1; j<n; ++j)
            a[i][j] /= a[i][i];
      for (int j=0; j<n; ++j)
            if (j != i && abs (a[j][i]) > EPS)
                  for (int k=i+1; k<n; ++k)
                        a[j][k] -= a[i][k] * a[j][i];
}

cout << det;
```