

euclid

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

min_cost_flow

```
struct MinCostFlow{
    int n;
    vector<vector<int>> adj, cst, cap;
    const int INF = 1e9;

    MinCostFlow(int n):n(n){
        adj=vector(n, vector<int>());
        cst=vector(n, vector<int>(n,0));
        cap=vector(n, vector<int>(n,0));
    }

    void add_edge(int from,int to,int capacity,int cost){
        adj[from].push_back(to);
        adj[to].push_back(from);
        cst[from][to] = cost;
        cst[to][from] = -cost;
        cap[from][to] = capacity;
    }

    void shortest_paths(int v0, vector<int>& d, vector<int>& p) {
        d.assign(n, INF);
        d[v0] = 0;
        vector<bool> inq(n, false);
        queue<int> q;
        q.push(v0);
        p.assign(n, -1);

        while (!q.empty()) {
            int u = q.front();
            q.pop();
            inq[u] = false;
            for (int v : adj[u]) {
                if (cap[u][v] > 0 && d[v] > d[u] + cst[u][v]) {
                    d[v] = d[u] + cst[u][v];
                    p[v] = u;
                    if (!inq[v]) {
                        inq[v] = true;
                        q.push(v);
                    }
                }
            }
        }
    }

    int min_cost_flow(int K, int s, int t) {
        int flow = 0;
        int cost = 0;
        vector<int> d, p;
        while (flow < K) {
            shortest_paths(s, d, p);
            if (d[t] == INF)
                break;

            // find max flow on that path
            int f = K - flow;
            int cur = t;
            while (cur != s) {
                f = min(f, cap[p[cur]][cur]);
                cur = p[cur];
            }

            // apply flow
            flow += f;
            cost += f * d[t];
            cur = t;
            while (cur != s) {
                cap[p[cur]][cur] -= f;
                cap[cur][p[cur]] += f;
                cur = p[cur];
            }
        }

        if (flow < K)
            return -1;
        else
            return cost;
    }
};
```

fft

```
using cd=complex<double>;
const double PI=acos(-1);

void fft(vector<cd>&a, bool invert){
    int n=(int)a.size();
    if(n==1)
        return;
    vector<cd>a0(n/2),a1(n/2);
    for(int i=0;2*i<n;i++){
        a0[i]=a[2*i];
        a1[i]=a[2*i+1];
    }
    fft(a0,invert);
    fft(a1,invert);
    double ang=2*PI/n*(invert?-1:1);
    cd w(1),wn(cos(ang),sin(ang));
    for(int i=0;2*i<n;i++){
        a[i]=a0[i]+w*a1[i];
        a[i+n/2]=a0[i]-w*a1[i];
        if(invert){
            a[i]/=2;
            a[i+n/2]/=2;
        }
        w*=wn;
    }
}

// polynomial multiplication
vector<ll>multiply(vector<int>&a, vector<int>&b){
    vector<cd>fa(a.begin(),a.end()),fb(b.begin(),b.end());
    int n=1;
    while(n<int(a.size())+b.size())
        n<<=1;
    fa.resize(n);
    fb.resize(n);
    fft(fa,0);
    fft(fb,0);
    for (int i=0;i<n;i++)
        fa[i]*=fb[i];
    fft(fa,1);
    vector<ll>result(n);
    for(int i=0;i<n;i++)
        result[i]=round(fa[i].real());
    return result;
}
```

setup

```
/*
setxkbmap us -option caps:escape
~/.vimrc

set number
set relativenumber
syntax enable
set autoindent
set tabstop=2
set shiftwidth=2
set wrap
set scrolloff=20
filetype plugin indent on
autocmd FileType cpp setlocal cindent

Makefile

CXX = g++
CXXFLAGS = -std=c++20 -O2 -Wall -DLOC

%: %.cpp
$(CXX) $(CXXFLAGS) $< -o $@

*/
#include<bits/stdc++.h>
using namespace std;
typedef long long ll;
typedef long double ld;
#define fwd(i,a,b) for(int i=(a); i<(b);i++)
#define rep(i,n) fwd(i,0,n)
#define all(X) (X).begin(), (X).end()
#define sz(X)((int)(X).size())
#define st first
#define nd second
#define pb push_back
typedef vector<int> vi;
typedef pair<int,int> pii;

#ifndef LOC
template<typename T1,typename T2>
auto& operator<<(ostream& out, pair<T1, T2> a) {return out<<"("<<a.st<<, " <<a.nd<<")";}
template<typename T>
auto& operator<<(ostream& out, vector<T>& a) {
    out<<"{";
    int cnt=0;
    for(auto b:a){
        cnt++;
        out<<>;
        if(cnt!=a.size())
            out<<", ";
    }
}
```

```

    return out<<"";
}

#define debug(x) cerr<< "[" #x "]: "<<x<<"\n";
#else
#define debug(x) ;
#endif

void solve(){

int main(){
    cin.tie(0);cout.tie(0);ios::sync_with_stdio(false);
    int t=1;cin>t;
    while(t--)solve();
    return 0;
}

```

li_chao

```

typedef pair<ll,ll>line;

struct LCT{
    int n;
    vector<line>lines;
    LCT(int n):n(n){
        lines=vector<line>(4*n,{0,1e18});
    }
    ll ev(line a,int x){
        return a.first*x+a.second;
    }
    void add_line(line nw,int v,int l,int r){
        int m=(l+r)/2;
        bool lef=ev(nw,l)<ev(lines[v],l);
        bool mid=ev(nw,m)<ev(lines[v],m);
        if(mid)
            swap(lines[v],nw);
        if(r-l==1)
            return;
        else if(lef!=mid)
            add_line(nw,2*v,l,m);
        else
            add_line(nw,2*v+1,m,r);
    }
    void add_line(line nw){
        add_line(nw,1,0,n);
    }
    ll get(int x,int v,int l,int r){
        int m=(l+r)/2;
        if(r-l==1)
            return ev(lines[v],x);
        else if(x<m)
            return min(ev(lines[v],x),get(x,2*v,l,m));
        else
            return min(ev(lines[v],x),get(x,2*v+1,m,r));
    }
    ll get(int x){
        return get(x,1,0,n);
    }
};

```

hash_string

```

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

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

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

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

```

tarjan _ bridge

```
int timer,tin[maxN],low[maxN];
bool vis[maxN];
vi nodes[maxN];
vector<pii>bridges;

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

max _ flow

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

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

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

    ll bfs(int s,int t,vector<int>&p){
        fill(p.begin(),p.end(),-1);
        p[s]=-2;
        queue<pair<int,int>>q;
        q.push({s,le9});
        while(!q.empty()){
            int c=q.front().first;
            ll f=q.front().second;
            q.pop();
            for(int x:adj[c]){
                if(p[x]==-1&&cp[c][x]){
                    p[x]=c;
                    ll r=min(f,cp[c][x]);
                    if(x==t)
                        return r;
                    q.push({x,r});
                }
            }
        }
        return 0;
    }

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

z _ algorithm

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

```

        }
        if(i + z[i] > r) {
            l = i;
            r = i + z[i];
        }
    }
    return z;
}

```

modulo_int

```

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

namespace std{template<>struct hash<M>{
    inline size_t operator()(const M&x) const{return x.val;}
};}
template<class T>bool operator<(T at,T bt){M b(bt);M a(at);return a.val<b.val;}
ostream&operator<<(ostream&s,M m){s<<m.val;return s;}
istream&operator>>(istream&s,M&m){s>>m.val;return s;}

```

fenwick

```

struct FT {
    vector<ll>s;
    FT(int n):s(n){}
    void upd(int i,int x){
        for(;i<sz(s);i|=i+1)s[i]+=x;
    }
    ll qry(int i){
        ll r=0;
        for(;i>0;i&=i-1)r+=s[i-1];
        return r;
    }
};

struct FT2 {
    vector<vi>ys;vector<FT>ft;
    FT2(int h):ys(h){}
    void inform(int x,int y){
        for(;x<sz(ys);x|=x+1)ys[x].pb(y);
    }
    void init(){
        for(vi&v:ys)sort(all(v)),ft.pb(sz(v));
    }
    int ind(int x,int y){
        return(lower_bound(all(ys[x]),y)-ys[x].begin()));
    }
    void upd(int x,int y,int dif){
        for(;x<sz(ys);x|=x+1)
            ft[x].upd(ind(x,y),dif);
    }
    ll qry(int x,int y){
        ll r=0;
        for(;x;x&=x-1)
            r+=ft[x-1].qry(ind(x-1,y));
        return r;
    }
    ll qry(int x1,int y1,int x2,int y2){
        return qry(x2,y2)-qry(x2,y1)-qry(x1,y2)+qry(x1,y1);
    }
};

```

convex_hull

```

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

int orientation(pt a, pt b, pt c) {
    double v = a.x*(b.y-c.y)+b.x*(c.y-a.y)+c.x*(a.y-b.y);

```

```

    if (v < 0) return -1; // clockwise
    if (v > 0) return +1; // counter-clockwise
    return 0;
}

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

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

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

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

```

suffix _ array

```

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

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

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

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

```

```

        ans += 1 << k;
        i += 1 << k;
        j += 1 << k;
    }
    return ans;
}

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

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

```