Contents

1 Setups

1.1 vimrc [6c9876]

```
se nu ai rnu cin ts=4 sw=4 | sy on
inoremap {<CR> {<CR>}<Esc>O
inoremap jk <Esc>
```

1.2 pbds [9f7c3e]

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

template <typename T>
using ordered_set = tree<T,null_type,less
    <T>,rb_tree_tag,tree_order_statistics_node_update>;

int main(){
    ordered_set<int> st;
    st.insert(1);
    st.find_by_order(0);//iterator to 1
    st.order_of_key(1);//returns 0
}
```

1.3 terminal [46fc34]

```
-- terminal --
$ setxkbmap -option caps:swapescape
```

1.4 debug [33c0d3]

```
#ifdef MIKU
string
     dbmc = "\033[1;38;2;57;197;187m", dbrs = \033[0m;
#define debug
    (x...) cout << dbmc << "[" << #x << "] : ", dout(x)
void dout() { cout << dbrs << endl; }
template <typename T, typename ...U>
void dout(T t, U ...u) { cout
     << t << sizeof...(u) ? ", " : ""; dout(u...); }
#else
#define debug(...) 39
#endif

int main(){
    int a = 49;
    char c = '8';
    debug(a);// outputs "[a] : 49"
    debug(a, c); // outputs "[a, c] : 49, 8"
    debug("PCCORZ"); // outputs "["PCCORZ"] : PCCORZ"
    debug(); // outputs "[] : "
}
```

1.5 template [5116af]

```
#include <bits/stdc++.h>
using namespace std;
#define fs first
#define sc second
#define F first
#define S second
#define FOR(i, j, k) for (int i = j, Z = k; i < Z; i++)
using ll = long long;
using lll = __int128_t;
typedef pair<int, int> pii;
typedef tuple<int,int,int> tiii;
typedef pair<ll,ll> pll


int main(){
}
```

2 Graph

2.1 Dominator Tree [3b89c3]

```
struct DominatorTree{
  //1-indexed
  //not reachable from s -> not on tree
  int n;
  vector<vector<int>> G,rG;
  vector<int> pa,dfn,id;
  int dfnCnt;
  vector<int> semi,idom,best;
  vector<vector<int>> ret;
  void init(int _n){
    n=_n;
    G = rG = ret = vector<vector<int>>(n+1);
    pa = dfn = id = vector<int>(n+1,-1);
    dfnCnt = 0;
    semi = idom = best = vector<int>(n+1,-1);
  }
  void add_edge(int u,int v){
    G[u].push_back(v);
    rG[v].push_back(u);
  }
  void dfs(int u){
    id[dfn[u]=++dfnCnt]=u;
    for(auto v:G[u]) if(!dfn[v]){
      dfs(v),pa[dfn[v]]=dfn[u];
    }
  }
  int find(int y,int x){
    if(y<=x)return y;
    int tmp=find(pa[y],x);
    if(semi[best[y]]>semi[best[pa[y]]])
      best[y]=best[pa[y]];
    return pa[y]=tmp;
  }
  void tarjan(int root){
    dfnCnt=0;
    for(int i=1;i<=n;++i){
      dfn[i]=idom[i]=0;
      ret[i].clear();
      best[i]=semi[i]=i;
    }
    dfs(root);
    for(int i=dfnCnt;i>1;--i){
      int u=id[i];
      for(auto v:rG[u]) if(v=dfn[v]){
        find(v,i);
        semi[i]=min(semi[i],semi[best[v]]);
      }
      ret[semi[i]].push_back(i);
      for(auto v:ret[pa[i]]){
        find(v,pa[i]);
        idom[v
            ] = semi[best[v]]==pa[i] ? pa[i] : best[v];
      }
      ret[pa[i]].clear();
    }
    for(int i=2; i<=dfnCnt; ++i){
      if(idom[i]!=semi[i]) idom[i]=idom[idom[i]];
      ret[id[idom[i]]].push_back(id[i]);
    }
  }
  vector<vector<int>> solve(int s){
    tarjan(s);
    return ret;
  }
};
```

2.2 Incremental SCC [d8b556]

```
struct IncrementalSCC{
#define pii pair<int,int>
#define fs first
#define sc second
#define tiii tuple<int,int,int>
  //if u == v : ans[i] = -1
  //if not connected : ans[i] = m
  //all 0-indexed
  int n;
  vector<int> ans;
  int m;
  vector<tiii> all;
  vector<int> SCC(int n,vector<vector<int>>& paths){
    vector<int> scc_id(n,-1),idx(n,-1),low(n,-1),st;
    int cnt = 0,gcnt = 0;
```

```
  function<void(int)> dfs = [&](int now)->void{
    low[now] = idx[now] = cnt++;
    st.push_back(now);
    for(auto nxt:paths[now]){
      if(scc_id[nxt] != -1)continue;
      if(idx[nxt] == -1){
        dfs(nxt);
        low[now] = min(low[now],low[nxt]);
      }
      else{
        low[now] = min(low[now],idx[nxt]);
      }
    }
    if(low[now] == idx[now]){
      int id = -1;
      while(id != now){
        id = st.back();
        st.pop_back();
        scc_id[id] = gcnt;
      }
      gcnt++;
    }
  };
  for(int i = 0;i<n;i++){
    if(scc_id[i] == -1)dfs(i);
  }
  //cerr<<"SCC: "<<n<<"::";for(int
       i = 0;i<n;i++)cerr<<scc_id[i]<<',';cerr<<endl;
  return scc_id;
}
vector<int> mapping;
void dc(int l,int r,vector<tiii> &edges){
  //cerr<<l<<' '<<r<<":"<<endl;
  if(l == r){
    for(auto
        &[id,_,__]:edges)ans[id] = min(ans[id],l);
    return;
  }
  int mid = (l+r)>>1;
  int cnt = 0;
  for(auto &[t,u,v]:edges){
    if(mapping[u] == -1)mapping[u] = cnt++;
    if(mapping[v] == -1)mapping[v] = cnt++;
  }
  n = cnt;
  vector<vector<int>> paths(n);
  vector<int> vv;
  for(auto &[t,u,v]:edges){
    vv.push_back(u);
    vv.push_back(v);
    u = mapping[u],v = mapping[v];
    if(t<=mid)paths[u].push_back(v);
  }
  //for(auto &i:vv)cerr<<i<<',';cerr<<endl;
  for(auto &i:vv)mapping[i] = -1;

  auto scc_id = SCC(n,paths);
  //for(auto
       [t,u,v]:edges)cerr<<t<<','<<u<<','<<v<<endl;
  //cerr<<endl;
  vector<tiii> vl,vr;
  for(auto &[t,u,v]:edges){
    if(scc_id[u] == scc_id[v]){
      ans[t] = min(ans[t],mid);
      vl.push_back(tiii(t,u,v));
    }
    else{
      u = scc_id[u],v = scc_id[v];
      vr.push_back(tiii(t,u,v));
    }
  }
  vector<tiii>().swap(edges);
  dc(l,mid,vl);
  dc(mid+1,r,vr);
  return;
}
void add_edge(int u,int v){
  all.push_back(tiii(all.size(),u,v));
}
vector<tiii> solve(){//[time,u,v]
  m = all.size();
  vector<tiii> ret(m);
  for(auto [t,u,v]:all)ret[t] = tiii(m,u,v);
  for(auto [t,u,v]:all)n = max({n,u,v});
  n++;
  ans = vector<int>(m,m);
  for(auto [t,u,v]:all){
    if(u == v)ans[t] = -1;
  }
  mapping = vector<int>(n,-1);
  dc(0,m,all);
  for(int i = 0;i<m;i++)get<0>(ret[i]) = ans[i];
  return ret;
}
IncrementalSCC(){
  ans.clear();
  n = m = 0;
}
#undef tiii
#undef pii
#undef fs
#undef sc
};
```

2.3 Block-Cut Tree [f44682]

```
struct BlockCutTree{
  //0-indexed
  //returns a forest if the graph is not connected
  vector<vector<int>> g;
  vector<vector<int>> groups;
  vector<vector<int>> tr;
  vector<int> idx,low,st;
  int cnt,gcnt;
  int n;
  RoundSquareTree(int _n = 0){
    cnt = gcnt = 0;
    n = _n;
    g = vector<vector<int>>(n);
  }
  void add_edge(int a,int b){//adds bidirectional edges
    g[a].push_back(b);
    g[b].push_back(a);
  }
  void dfs(int now){
    idx[now] = low[now] = cnt++;
    st.push_back(now);
    for(auto nxt:g[now]){
      if(idx[nxt] == -1){
        dfs(nxt);
        low[now] = min(low[now],low[nxt]);
        if(low[nxt] == idx[now]){
          int id = -1;
          tr.push_back(vector<int>());
          while(id != nxt){
            id = st.back();st.pop_back();
            groups[id].push_back(gcnt);
            tr[id].push_back(gcnt+n);
            tr[gcnt+n].push_back(id);
          }
          groups[now].push_back(gcnt);
          tr[now].push_back(gcnt+n);
          tr[gcnt+n].push_back(now);
          gcnt++;
        }
      }
      else idx[now] = min(idx[now],idx[nxt]);
    }
    return;
  }
  vector<vector<int>> solve(){//
      returns the tree (round vertices numbered [0,n))
    idx = low = vector<int>(n,-1);
    tr = vector<vector<int>>(n);
    for(int i = 0;i<n;i++){
      if(idx[i] == -1)dfs(i);
    }
    return tr;
  }
};
```

2.4 Euler Tour [a4ce3c]

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

struct EulerTour{
  //undirected graph,0-indexed,fails if doesn't exist
  //returns the order of edges
#define pii pair<int,int>
  vector<vector<pii>> g;
  vector<int> ptr;
  vector<bool> vis;
```

```
  vector<int> re;
  int n,ecnt;
  void init(int _n){
    n = _n;
    ecnt = 0;
    g = vector<vector<pii>>(n);
    ptr = vector<int>(n);
  }
  void add_edge(int a,int b,int id = -1){
    if(id == -1)id = ecnt;
    g[a].push_back(pii(b,id));
    g[b].push_back(pii(a,id));
    ecnt++;
  }
  void dfs(int now){
    for(int &i = ptr[now];i<g[now].size();i++){
      auto [to,eid] = g[now][i];
      if(vis[eid])continue;
      vis[eid] = true;
      dfs(to);
      re.push_back(eid);
    }
    return;
  }
  vector<int> solve(int s){
    re.clear();
    vis = vector<bool>(ecnt,0);
    dfs(s);
    return re;
  }
#undef pii
};
```

3 Data Structure

3.1 Li Chao Tree [565209]

```
//range add line get min
//can even be used of modifies isn't range modify
#define ll long long
const ll SZ = 8e6+10;
const ll inf = 3e18;
vector<ll> all;
struct Line{
  ll m,b;
  Line(ll mm = 0,ll bb = 0):m(mm),b(bb){}
  ll operator()(ll k){
    return m*k+b;
  }
};
struct LiChao{
#define ls now*2+1
#define rs now*2+2
#define mid ((l+r)>>1)
  Line seg[SZ];
  LiChao(){
    fill(seg,seg+SZ,Line(0,inf));
  }
  void modify(int now,int l,int r,int s,int e,Line v){
    if(l == r){
      if(seg[now](all[l])>v(all[l]))swap(seg[now],v);
      return;
    }
    if(l>=s&&e>=r){
      if(seg
          [now](all[mid])>v(all[mid]))swap(seg[now],v);
      if(seg[now].m<v.m)modify(ls,l,mid,s,e,v);
      else modify(rs,mid+1,r,s,e,v);
    }
    else{
      if(mid>=s)modify(ls,l,mid,s,e,v);
      if(mid<e)modify(rs,mid+1,r,s,e,v);
    }
    return;
  }
  ll getval(int now,int l,int r,int p){
    if(l == r)return seg[now](all[p]);
    if(mid>=p)return
          min(seg[now](all[p]),getval(ls,l,mid,p));
    else return
          min(seg[now](all[p]),getval(rs,mid+1,r,p));
  }
  void add_line(int s,int e,Line v){
    modify(0,0,all.size()-1,s,e,v);
    return;
  }
  ll getmin(int p){
    return getval(0,0,all.size()-1,p);
  }
#undef ls
#undef rs
#undef mid
};
#undef ll long long
```

4 Geometry

4.1 Point [d6339e]

```
template<typename T = int>
struct Pt{
  T x,y;
  Pt (T xx = T(),T yy = T()):x(xx),y(yy){}
  Pt operator+(Pt b)const{return Pt(x+b.x,y+b.y);}
  Pt operator-(Pt b)const{return Pt(x-b.x,y-b.y);}
  T operator*(Pt b)const{return x*b.x+y*b.y;}
  T operator^(Pt b)const{return x*b.y-y*b.x;}
  T operator/(Pt b)const{return x*b.y-y*b.x;}
  bool operator
      <(Pt b)const{return x == b.x?y<b.y:x<b.x;}

  friend int dir(Pt a,Pt b){//returns sign(a ^ b)
    auto re = a ^ b;
    return re<0?-1:re>0?1:0;
  }
  friend bool onseg(Pt x,Pt s,Pt e){
    if(((e-x)^(s-x)) != 0)return false;
    else if((s-x)*(e-x)>0)return false;
    return true;
  }
  friend int
       intersect(Pt s1,Pt e1,Pt s2,Pt e2){//returns 0
       if doesn't intersect,1 if intersect,2 if on line
    if(onseg(s1,s2,e2)||onseg(e1,s2,
        e2)||onseg(s2,s1,e1)||onseg(e2,s1,e1))return 2;
    if(dir(s1-s2,e2-s2)*dir(e1-s2,e2-s2)<0&&
        dir(s2-s1,e1-s1)*dir(e2-s1,e1-s1)<0)return 1;
    return 0;
  }

};
```

4.2 Convex Hull [2a54da]

```
//needs Point.cpp
template<typename T = int>
struct ConvexHull{//returns in clockwise direction
  vector<Pt<T>> solve(vector<Pt<T>> v){
    sort(v.begin(),v.end());
    vector<Pt<T>> u,d;
    for(auto &i:v){
      while(u.size()>1&&((i-u.end()[-1])
          ^(u.end()[-2]-u.end()[-1]))>=0)u.pop_back();
      while(d.size()>1&&((i-d.end()[-1])
          ^(d.end()[-2]-d.end()[-1]))<=0)d.pop_back();
      u.push_back(i);
      d.push_back(i);
    }
    for(int i =
        1;i+1<d.size();i++)u.push_back(d.end()[-1-i]);
    return u;
  }
};
```

4.3 Minkowski sum [9db95e]

```
//needs Point template
template <typename T>
vector<Pt
    <T>> minkowski(vector<Pt<T>> va,vector<Pt<T>> vb){
  deque<Pt<T>> a,b;
  for(auto &i:va)a.push_back(i);
  for(auto &i:vb)b.push_back(i);
  Pt head = *min_element(a.begin(),a.end());
  while(a[0].x != head.x||a[0].y != head.y){
    a.push_back(a[0]);
    a.pop_front();
  }
  head = *min_element(b.begin(),b.end());
  while(b[0].x != head.x||b[0].y != head.y){
    b.push_back(b[0]);
    b.pop_front();
  }
  a.push_back(a[0]);
```

```
  b.push_back(b[0]);
  int p1 = 0,p2 = 0;
  vector<Pt<T>> re;
  while(p1 < a.size()&&p2 < b.size()){
    //cerr<<a
        .size()<<','<<b.size()<<":"<<p1<<' '<<p2<<endl;
    int dir = 0;
    re.push_back(a[p1]+b[p2]);
    if(p1+1 == a.size())dir = 1;
    else if(p2+1 == b.size())dir = 0;
    else
        if(((a[p1+1]-a[p1])^(b[p2+1]-b[p2]))>0)dir = 0;
    else dir = 1;
    if(dir == 0)p1++;
    else p2++;
  }
  return re;
}
```

5 String

5.1 Suffix Array (SAIS) [a683f1]

```
int SA[MXN * 2], H[MXN], RA[MXN];
namespace SAIS {
    bool _t[MXN * 2];
    int _s[MXN *
         2], _c[MXN * 2], x[MXN], _p[MXN], _q[MXN * 2];
    void pre(int *sa, int *c, int n, int z) {
        fill_n(sa, n, 0);
        copy_n(c, z, x);
    }
    void induce(int
         *sa, int *c, int *s, bool *t, int n, int z) {
        copy_n(c, z - 1, x + 1);
        FOR(i, 0, n) {
            if (sa[i] && !t[sa[i] - 1]) {
                sa[x[s[sa[i] - 1]]++] = sa[i] - 1;
            }
        }
        copy_n(c, z, x);
        for (int i = n - 1; i >= 0; i--) {
            if (sa[i] && t[sa[i] - 1]) {
                sa[--x[s[sa[i] - 1]]] = sa[i] - 1;
            }
        }
    }
    void sais(int *s, int *sa, int
         *p, int *q, bool *t, int *c, int n, int z) {
        bool uniq = t[n - 1] = true;
        int nn = 0, nmxz =
             -1, *nsa = sa + n, *ns = s + n, last = -1;
        fill_n(c, z, 0);
        FOR(i, 0, n) uniq &= ++c[s[i]] < 2;
        partial_sum(c, c + z, c);
        if (uniq) {
            FOR(i, 0, n) sa[--c[s[i]]] = i;
            return;
        }
        for (int i = n - 2; i >= 0; i--) {
            t[i] = (s[i] ==
                s[i + 1] ? t[i + 1] : s[i] < s[i + 1]);
        }
        pre(sa, c, n, z);
        FOR(i, 1, n) {
            if (t[i] && !t[i - 1]) {
                sa[--x[s[i]]] = p[q[i] = nn++] = i;
            }
        }
        induce(sa, c, s, t, n, z);
        FOR(i, 0, n) {
            if (sa[i] && t[sa[i]] && !t[sa[i] - 1]) {
                bool neq = last < 0 || !equal(s + sa[
                    i], s + p[q[sa[i]] + 1], s + last);
                ns[q[last = sa[i]]] = nmxz += neq;
            }
        }
        sais(ns, nsa,
            p + nn, q + n, t + n, c + z, nn, nmxz + 1);
        pre(sa, c, n, z);
        for (int i = nn - 1; i >= 0; i--) {
            sa[--x[s[p[nsa[i]]]]] = p[nsa[i]];
        }
        induce(sa, c, s, t, n, z);
    }
    void mkhei(int n) {
        for (int i = 0, j = 0; i < n; i++) {
            if (RA[i]) {
                for (; i + j < n
                     && SA[RA[i] - 1] + j < n && _s[i +
                     j] == _s[SA[RA[i] - 1] + j]; ++j);
                H[RA[i]] = j, j = max(0, j - 1);
            }
        }
    }
    void build(int *s, int n, int mxc) {
        copy_n(s, n, _s), _s[n] = 0;
        sais(_s, SA, _p, _q, _t, _c, n + 1, mxc);
        copy_n(SA + 1, n, SA);
        FOR(i, 0, n) RA[SA[i]] = i;
        mkhei(n);
        copy(H + 1, H + n, H);
    }
}
```

5.2 AC automaton [c073c7]

```
#define FOR(i, j, k) for (int i = j, Z = k; i < Z; i++)

struct AC {
    int nc;
    char c[MXN];
    int pi[MXN], p[MXN], nxt[MXN][MXC];
    void init() {
        nc = 2;
        fill(nxt[0], nxt[0] + MXC, 1);
        fill(nxt[1], nxt[1] + MXC, -1);
    }
    int add_node(int par, char _c) {
        c[nc] = _c;
        p[nc] = par;
        fill(nxt[nc], nxt[nc] + MXC, -1);
        return nc++;
    }
    int push(string &s) {
        int now = 1;
        for (auto &i : s) {
            if (nxt[now][i - 'a'] == -1)
                nxt[now][i - 'a'] = add_node(now, i);
            now = nxt[now][i - 'a'];
        }
        return now;
    }
    void build() {
        queue<int> q;
        pi[1] = 0;
        FOR(i, 0, MXC) {
            if (nxt[1][
                i] == -1) nxt[1][i] = nxt[pi[1]][i];
            else q.push(nxt[1][i]);
        }
        while (q.size()) {
            int id = q.front();
            q.pop();
            pi[id] = nxt[pi[p[id]]][c[id] - 'a'];
            FOR(i, 0, MXC) {
                if (nxt[id][i]
                    == -1) nxt[id][i] = nxt[pi[id]][i];
                else q.push(nxt[id][i]);
            }
        }
    }
};
```

6 Math

6.1 module int [a4a56c]

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

template <int mod = 998244353>
struct mint {
    int x;
    mint() : x(0) {}
    mint(int _x) : x((_x % mod + mod) % mod) {}
    operator int() const {
        return x;
    }
    template <typename T>
    mint operator+(T t) {
        mint o = mint(t);
        int y = x + o.x;
```

```
        y -= (y >= mod ? mod : 0);
        return mint(y);
    }
    template <typename T>
    mint &operator+=(T t) {
        return (*this = operator+(t));
    }
    template <typename T>
    mint operator-(T t) {
        mint o = mint(t);
        int y = x - o.x;
        y += (y < 0 ? mod : 0);
        return mint(y);
    }
    template <typename T>
    mint &operator-=(T t) {
        return (*this = operator-(t));
    }
    template <typename T>
    mint operator*(T t) {
        mint o = mint(t);
        return mint((ll) x + o.x % mod);
    }
    template <typename T>
    mint &operator*=(T t) {
        return (*this = operator*(t));
    }
    template <typename T>
    mint POW(T t) {
        int b = int(t);
        mint a(x), ans(1);
        while (b) {
            if (b & 1) ans *= a;
            b >>= 1;
            a *= a;
        }
        return ans;
    }
    template <typename T>
    mint inv() {
        return POW(mod - 2);
    }
    template <typename T>
    mint operator/(T t) {
        mint o = mint(t);
        return operator*(o.inv());
    }
    template <typename T>
    mint &operator/=(T t) {
        return (*this = operator/(t));
    }
};
```

6.2 FFT [263d47]

```
#define FOR(i, j, k) for (int i = j, Z = k; i < Z; i++)
template <typename T>
struct FFT {
    const T pi = acos(-1);
    complex<T> cis(T theta) {
        return complex<T>(cos(theta), sin(theta));
    }
    complex<T> OMEGA(int n, int k) {
        return cis(pi * 2 * k / n);
    }
    void apply(complex<T> *a, int N, bool inv) {
        auto REVERSE = [&](int x) -> int {
            int ans = 0;
            for (int i = 1; i < N; i <<= 1) {
                ans <<= 1;
                if (i & x) ans |= 1;
            }
            return ans;
        };
        FOR(i, 0, N) {
            int r = REVERSE(i);
            if (i < r) swap(a[i], a[r]);
        }
        for (int w = 1; w < N; w <<= 1) {
            int omega_n = w << 1;
            for (int
                 omega_k = 0; omega_k < w; omega_k++) {
                complex<T> omega = OMEGA(
                    omega_n, (inv ? -1 : 1) * omega_k);
                for (int s = 0; s < N; s += omega_n) {
                    complex<T> &L = a[s + omega_k
                        ], &R = a[s + omega_k + w];
                    complex<T> l = L, r = omega * R;
                    L = l + r;
                    R = l - r;
                }
            }
        }
        if (inv) {
            FOR(i, 0, N) a[i] /= N;
        }
    }
};
#undef FOR
```

6.3 FWT [a168b9]

```
#include <bits/stdc++.h>
using namespace std;
#define fs first
#define sc second
#define FOR(i, j, k) for (int i = j, Z = k; i < Z; i++)
using ll = long long;
typedef pair<int, int> pii;

typedef pair<pii, pii> MAT;

template <int mod = 998244353>
struct mint {
    int x;
    mint() : x(0) {}
    mint(int _x) : x(_x) {}
    mint operator+(mint o) {
        int y = x + o.x;
        y -= (y >= mod ? mod : 0);
        return mint(y);
    }
    mint operator*(int y) {
        y += (y < 0 ? mod : 0);
        return mint((ll) x * y % mod);
    }
    mint operator*(mint o) {
        return mint((ll) x * o.x % mod);
    }
    mint inv() {
        int b = mod - 2, a = x;
        int ans = 1;
        while (b) {
            if (b & 1) ans = (ll) ans * a % mod;
            b >>= 1;
            a = (ll) a * a % mod;
        }
        return mint(ans);
    }
};

template <typename T = int>
struct FWT {
    enum FWT_TYPE {
        AND,
        OR,
        XOR
    };
    const MAT mat[3] = {
        {{1, 1}, {0, 1}},
        {{1, 0}, {1, 1}},
        {{1, 1}, {1, -1}}
    };
    const MAT tam[3] = {
        {{1, -1}, {0, 1}},
        {{1, 0}, {-1, 1}},
        {{1, 1}, {1, -1}}
    };
    FWT() {}
    void btf(T &L, T &R, MAT &m) {
        T l = L, r = R;
        L = l * m.fs.fs + r * m.fs.sc;
        R = l * m.sc.fs + r * m.sc.sc;
    }
    void apply(T *a, int n, bool inv, FWT_TYPE tp) {
        MAT m = (inv ? tam : mat)[tp];
        for (int w = 1; w < n; w <<= 1) {
            FOR(i, 0, n) if (i & w) {
                btf(a[i - w], a[i], m);
            }
        }
        if (tp == FWT_TYPE::XOR && inv) {
            T n_ = T(n).inv();
            FOR(i, 0, n) a[i] = a[i] * n_;
```

```
        }
    }
};
```