Contents

Basic

makefile

```
CPP = g++ -std=c++11 -O2

name = $(basename $(file))
type = $(suffix $(file))
exe = $(name).out

$(exe): $(file)
ifeq ($(type),.cpp)
    $(CPP) -D AC -o $(exe) $(name).cpp
endif

clean:
    rm *.out
```

/.vimrc

```
set nu      " 顯示行號
set tabstop=4 " tab 的字元數
set ai
set smartindent
set softtabstop=4
set shiftwidth=4
set cindent

se ai ar sm nu rnu is
se mouse=a bs=2 so=6 ts=4 ttm=100

nmap <F2> :! gedit %<.in %<*.in &<CR>
nmap <F4> :! date > %<.pt; cat -n % > %<.pt; lpr %<.pt
    <CR>
nmap <F8> :! clear ; python3 % <CR>
nmap <F9> :! clear ; make file=%; for i in %<*.in; do
    echo $i; ./%<.out < $i; echo -e "\n"; done <CR>
nmap <F10> :! clear ; make file=%; ./%<.out <CR>
nmap <C-I> :! read -p "CASE:" CASE; gedit %<_$CASE.in <
    CR>
```

default code

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

int main(){
#ifndef AC
    freopen("","r",stdin);
#endif
    ios_base::sync_with_stdio(false);
    cin.tie(0);
}
```

debug list

```
模板要記得 init
把邊界條件都加入測資
邊界條件（過程溢位，題目數據範圍），會不會爆 long long
是否讀錯題目
環狀or凸包問題一定要每種都算n次
比較容易有問題的地方換人寫
注意公式有沒有推錯或抄錯
精度誤差 sqrt(大大的東西) + EPS
測試 %lld or %I64d
喇分 random_suffle 隨機演算法
```

Flow

Dinic

```cpp
const int INF = 1<<29;
struct Dinic{ //O(VVE)
  static const int MAXV = 5003;
  struct Edge{
    int from, to, cap, flow;
  };

  int n, m, s, t, d[MAXV], cur[MAXV];
  vector<Edge> edges;
  vector<int> G[MAXV];

  void init(int _n=MAXV){
    edges.clear();
    for (int i=0; i<_n; i++)G[i].clear();
  }

  void AddEdge(int from, int to, int cap){
    edges.push_back( {from,to,cap,0} );
    edges.push_back( {to,from,0,0} );
    m = edges.size();
    G[from].push_back(m-2);
    G[to].push_back(m-1);
  }

  bool dinicBFS(){
    memset(d,-1,sizeof(d));
    queue<int> que;
    que.push(s); d[s]=0;
    while (!que.empty()){
      int u = que.front(); que.pop();
      for (int ei:G[u]){
        Edge &e = edges[ei];
        if (d[e.to]<0 && e.cap>e.flow){
          d[e.to]=d[u]+1;
          que.push(e.to);
        }
      }
    }
    return d[t]>=0;
  }

  int dinicDFS(int u, int a){
    if (u==t || a==0)return a;
    int flow=0, f;
    for (int &i=cur[u]; i<(int)G[u].size(); i++){
      Edge &e = edges[ G[u][i] ];
      if (d[u]+1!=d[e.to])continue;
      f = dinicDFS(e.to, min(a, e.cap-e.flow) );
      if (f>0){
        e.flow += f;
        edges[ G[u][i]^1 ].flow -=f;
        flow += f;
        a -= f;
        if (a==0)break;
      }
    }
    return flow;
  }

  int maxflow(int s, int t){
    this->s = s, this->t = t;
    int flow=0, mf;
    while ( dinicBFS() ){
      memset(cur,0,sizeof(cur));
      while ( (mf=dinicDFS(s,INF)) )flow+=mf;
    }
    return flow;
  }
}dinic;

// s=0, t=1;
int fnd(int id ,int out=0){
  // out=0 入點 out=1 出點
  static int spr=1;
  //spr=2 時每個點分成入點,出點
  return id*spr+out+2;
```

```cpp
}
```

KM

```cpp
struct KM{
// Maximum Bipartite Weighted Matching (Perfect Match)
  static const int MXN = 650;
  static const int INF = 2147483647; // long long
  int n,match[MXN],vx[MXN],vy[MXN];
  int edge[MXN][MXN],lx[MXN],ly[MXN],slack[MXN];
  // ^^^^ long long
  void init(int _n){
    n = _n;
    for (int i=0; i<n; i++)
      for (int j=0; j<n; j++)
        edge[i][j] = 0;
  }
  void add_edge(int x, int y, int w){ // long long
    edge[x][y] = w;
  }
  bool DFS(int x){
    vx[x] = 1;
    for (int y=0; y<n; y++){
      if (vy[y]) continue;
      if (lx[x]+ly[y] > edge[x][y]){
        slack[y] = min(slack[y], lx[x]+ly[y]-edge[x][y
          ]);
      } else {
        vy[y] = 1;
        if (match[y] == -1 || DFS(match[y])){
          match[y] = x;
          return true;
        }
      }
    }
    return false;
  }
  int solve(){
    fill(match,match+n,-1);
    fill(lx,lx+n,-INF);
    fill(ly,ly+n,0);
    for (int i=0; i<n; i++)
      for (int j=0; j<n; j++)
        lx[i] = max(lx[i], edge[i][j]);
    for (int i=0; i<n; i++){
      fill(slack,slack+n,INF);
      while (true){
        fill(vx,vx+n,0);
        fill(vy,vy+n,0);
        if ( DFS(i) ) break;
        int d = INF; // long long
        for (int j=0; j<n; j++)
          if (!vy[j]) d = min(d, slack[j]);
        for (int j=0; j<n; j++){
          if (vx[j]) lx[j] -= d;
          if (vy[j]) ly[j] += d;
          else slack[j] -= d;
        }
      }
    }
    int res=0;
    for (int i=0; i<n; i++)
      res += edge[match[i]][i];
    return res;
  }
}graph;
```

KM

```cpp
const int MAX_N = 400 + 10;
const ll INF64 = 0x3f3f3f3f3f3f3f3fLL;
int nl , nr;
int pre[MAX_N];
ll slack[MAX_N];
ll W[MAX_N][MAX_N];
ll lx[MAX_N] , ly[MAX_N];
int mx[MAX_N] , my[MAX_N];
bool vx[MAX_N] , vy[MAX_N];
```

```cpp
void augment(int u) {
    if(!u) return;
    augment(mx[pre[u]]);
    mx[pre[u]] = u;
    my[u] = pre[u];
}
inline void match(int x) {
    queue<int> que;
    que.push(x);
    while(1) {
        while(!que.empty()) {
            x = que.front();
            que.pop();
            vx[x] = 1;
            REP1(y , 1 , nr) {
                if(vy[y]) continue;
                ll t = lx[x] + ly[y] - W[x][y];
                if(t > 0) {
                    if(slack[y] >= t) slack[y] = t ,
                        pre[y] = x;
                    continue;
                }
                pre[y] = x;
                if(!my[y]) {
                    augment(y);
                    return;
                }
                vy[y] = 1;
                que.push(my[y]);
            }
        }
        ll t = INF64;
        REP1(y , 1 , nr) if(!vy[y]) t = min(t , slack[y
            ]);
        REP1(x , 1 , nl) if(vx[x]) lx[x] -= t;
        REP1(y , 1 , nr) {
            if(vy[y]) ly[y] += t;
            else slack[y] -= t;
        }
        REP1(y , 1 , nr) {
            if(vy[y] || slack[y]) continue;
            if(!my[y]) {
                augment(y);
                return;
            }
            vy[y] = 1;
            que.push(my[y]);
        }
    }
}
int main() {
    int m;
    RI(nl , nr , m);
    nr = max(nl , nr);
    while(m--) {
        int x , y;
        ll w;
        RI(x , y , w);
        W[x][y] = w;
        lx[x] = max(lx[x] , w);
    }
    REP1(i , 1 , nl) {
        REP1(x , 1 , nl) vx[x] = 0;
        REP1(y , 1 , nr) vy[y] = 0 , slack[y] = INF64;
        match(i);
    }
    ll ans = 0LL;
    REP1(x , 1 , nl) ans += W[x][mx[x]];
    PL(ans);
    REP1(x , 1 , nl) printf("%d%c",W[x][mx[x]] ? mx[x]
        : 0," \n"[x == nl]);
    return 0;
}
```

min cost max flow

```cpp
// from: https://github.com/bobogei81123/bcw_codebook/
    blob/master/codes/Graph/Flow/CostFlow.cpp
typedef pair<long long, long long> pll;
struct CostFlow {
```

```cpp
    static const int MXN = 205;
    static const long long INF = 1029384756102938475LL;
    struct Edge {
        int v, r;
        long long f, c;
    };
    int n, s, t, prv[MXN], prvL[MXN], inq[MXN];
    long long dis[MXN], fl, cost;
    vector<Edge> E[MXN];
    void init(int _n, int _s, int _t) {
        n = _n; s = _s; t = _t;
        for (int i=0; i<n; i++) E[i].clear();
        fl = cost = 0;
    }
    void add_edge(int u, int v, long long f, long long c)
        {
        E[u].PB({v, SZ(E[v])   , f,  c});
        E[v].PB({u, SZ(E[u])-1, 0, -c});
    }
    pll flow() {
        while (true) {
            for (int i=0; i<n; i++) {
                dis[i] = INF;
                inq[i] = 0;
            }
            dis[s] = 0;
            queue<int> que;
            que.push(s);
            while (!que.empty()) {
                int u = que.front(); que.pop();
                inq[u] = 0;
                for (int i=0; i<SZ(E[u]); i++) {
                    int v = E[u][i].v;
                    long long w = E[u][i].c;
                    if (E[u][i].f > 0 && dis[v] > dis[u] + w) {
                        prv[v] = u; prvL[v] = i;
                        dis[v] = dis[u] + w;
                        if (!inq[v]) {
                            inq[v] = 1;
                            que.push(v);
                        }
                    }
                }
            }
            if (dis[t] == INF) break;
            long long tf = INF;
            for (int v=t, u, l; v!=s; v=u) {
                u=prv[v]; l=prvL[v];
                tf = min(tf, E[u][l].f);
            }
            for (int v=t, u, l; v!=s; v=u) {
                u=prv[v]; l=prvL[v];
                E[u][l].f -= tf;
                E[v][E[u][l].r].f += tf;
            }
            cost += tf * dis[t];
            fl += tf;
        }
        return {fl, cost};
    }
}flow;
```

Geometry

2D Point Template

```cpp
typedef double T;
struct Point {
    T x,y;
    Point (T _x=0, T _y=0):x(_x),y(_y){}

    bool operator < (const Point &b)const{
        return atan2(y,x) < atan2(b.y,b.x);
    }
    bool operator == (const Point &b)const{
        return atan2(y,x) == atan2(b.y,b.x);
    }
    Point operator + (const Point &b)const{
```

```cpp
    return Point(x+b.x,y+b.y);
  }
  Point operator - (const Point &b)const{
    return Point(x-b.x,y-b.y);
  }
  T operator * (const Point &b)const{
    return x*b.x + y*b.y;
  }
  T operator % (const Point &b)const{
    return x*b.y - y*b.x;
  }
  Point operator * (const T &d)const{
    return Point(d*x,d*y);
  }
  T abs2() { return x*x+y*y; }
  T abs() { return sqrt( abs2() ); }
};
typedef Point pdd;
inline double abs2(pdd a){
  return a.abs2();
}
```

Intersection of two circle

```cpp
typedef Point pdd;
typedef ld double;
vector<pdd> interCircle(pdd o1, double r1, pdd o2,
    double r2) {
  ld d2 = (o1 - o2).abs2();
  ld d = sqrt(d2);
  if (d < fabs(r1-r2)) return {};
  if (d > r1+r2) return {};
  pdd u = 0.5*(o1+o2) + ((r2*r2-r1*r1)/(2.0*d2))*(o1-o2
    );
  double A = sqrt((r1+r2+d) * (r1-r2+d) * (r1+r2-d) *
    (-r1+r2+d));
  pdd v = A / (2.0*d2) * pdd(o1.S-o2.S, -o1.F+o2.F);
  return {u+v, u-v};
}
```

Convex Hull

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

typedef long long LL;
const int MAXN = 100005;
const LL INF = (1LL)<<62;

struct Point{
    LL x, y;
    Point (LL x=0, LL y=0):x(x),y(y){}
    bool operator < (const Point &B)const {
        if (x!=B.x)return x<B.x;
        return y<B.y;
    }
    Point operator - (Point B){
        return Point(x-B.x,y-B.y);
    }
};
LL cross(Point A, Point B){
    return A.x*B.y-A.y*B.x;
}
LL Abs(LL x){
    return x>0?x:-x;
}
LL AreaU[MAXN], AreaD[MAXN];
void find_CH(int N, Point P[], LL Area[]){
    static vector<Point> U, D;
    static vector<int> Ui, Di;
    U.clear(), Ui.clear();
    D.clear(), Di.clear();
    int uz=0, dz=0;

    for (int i=0; i<N; i++){
        while (uz>=2 && cross(P[i]-U[uz-2],U[uz-1]-U[uz
            -2])<=0)U.pop_back(), Ui.pop_back(), uz--;
        if (uz<=1)AreaU[i]=0;
```

```cpp
        else AreaU[i] = AreaU[ Ui[uz-1] ] + Abs(cross(P
            [i]-U[0],U[uz-1]-U[0]));
        U.push_back(P[i]),Ui.push_back(i),uz++;

        while (dz>=2 && cross(P[i]-D[dz-2],D[dz-1]-D[dz
            -2])>=0)D.pop_back(), Di.pop_back(), dz--;
        if (dz<=1)AreaD[i]=0;
        else AreaD[i] = AreaD[ Di[dz-1] ] + Abs(cross(P
            [i]-D[0],D[dz-1]-D[0]));
        D.push_back(P[i]),Di.push_back(i),dz++;

        Area[i] = AreaU[i] + AreaD[i];
        //printf("Area[%d]=%lld\n",i ,Area[i]);
    }
    //puts("");
}

int N;
Point P[MAXN];
LL AreaL[MAXN], AreaR[MAXN];

int main(){
    input();

    find_CH(N,P,AreaL);
    for (int i=0; i<N; i++)P[i].x*=-1;
    reverse(P,P+N);
    find_CH(N,P,AreaR);
    reverse(AreaR,AreaR+N);
    reverse(P,P+N);

    LL Ans = min(AreaL[N-1],AreaR[0]);
    for (int i=0; i<N-1; i++){
        if (P[i].x!=P[i+1].x){
            Ans = min (Ans,AreaL[i]+AreaR[i+1]);
        }
    }
  if (P[0].x==P[N-1].x)Ans=0;
    printf("%lld\n",(Ans+1)/2LL);
}
```

外心 Circumcentre

```cpp
#include "2Dpoint.cpp"

pdd circumcentre(pdd &p0, pdd &p1, pdd &p2){
  pdd a = p1-p0;
  pdd b = p2-p0;
  double c1 = a.abs2()*0.5;
  double c2 = b.abs2()*0.5;
  double d = a % b;
  double x = p0.x + ( c1*b.y - c2*a.y ) / d;
  double y = p0.y + ( c2*a.x - c1*b.x ) / d;
  return pdd(x,y);
}
```

Smallest Covering Circle

```cpp
#include "circumcentre.cpp"
pair<pdd,double> SmallestCircle(int n, pdd _p[]){
  static const int MAXN = 1000006;
  static pdd p[MAXN];
  memcpy(p,_p,sizeof(pdd)*n);
  random_shuffle(p,p+n);

  double r2=0;
  pdd cen;
  for (int i=0; i<n; i++){
    if ( (cen-p[i]).abs2() <=r2)continue;
    cen = p[i], r2=0;
    for (int j=0; j<i; j++){
      if ( (cen-p[j]).abs2()<=r2 )continue;
      cen = (p[i]+p[j])*0.5;
      r2 = (cen-p[i]).abs2();
      for (int k=0; k<j; k++){
        if ( (cen-p[k]).abs2()<=r2 )continue;
        cen = circumcentre(p[i],p[j],p[k]);
        r2 = (cen-p[k]).abs2();
```

```
      }
    }
  }

  return {cen,r2};
}
// auto res = SmallestCircle(,);
```

Mathmatics

LinearPrime

```cpp
const int MAXP = 100; //max prime
vector<int> P;  // primes
void build_prime(){
  static bitset<MAXP> ok;
  int np=0;
  for (int i=2; i<MAXP; i++){
    if (ok[i]==0)P.push_back(i), np++;
    for (int j=0; j<np && i*P[j]<MAXP; j++){
      ok[ i*P[j] ] = 1;
      if ( i%P[j]==0 )break;
    }
  }
}
```

BigInt

```cpp
struct Bigint{
  static const int LEN = 60;
  static const int BIGMOD = 10000;
  int s;
  int vl, v[LEN];
  //  vector<int> v;
  Bigint() : s(1) { vl = 0; }
  Bigint(long long a) {
    s = 1; vl = 0;
    if (a < 0) { s = -1; a = -a; }
    while (a) {
      push_back(a % BIGMOD);
      a /= BIGMOD;
    }
  }
  Bigint(string str) {
    s = 1; vl = 0;
    int stPos = 0, num = 0;
    if (!str.empty() && str[0] == '-') {
      stPos = 1;
      s = -1;
    }
    for (int i=SZ(str)-1, q=1; i>=stPos; i--) {
      num += (str[i] - '0') * q;
      if ((q *= 10) >= BIGMOD) {
        push_back(num);
        num = 0; q = 1;
      }
    }
    if (num) push_back(num);
  }
  int len() const { return vl; /* return SZ(v); */ }
  bool empty() const { return len() == 0; }
  void push_back(int x) { v[vl++] = x; /* v.PB(x); */ }
  void pop_back() { vl--; /* v.pop_back(); */ }
  int back() const { return v[vl-1]; /* return v.back()
    ; */ }
  void n() { while (!empty() && !back()) pop_back(); }
  void resize(int nl) {
    vl = nl; fill(v, v+vl, 0);
    //   v.resize(nl); // fill(ALL(v), 0);
  }
  void print() const {
    if (empty()) { putchar('0'); return; }
    if (s == -1) putchar('-');
    printf("%d", back());
    for (int i=len()-2; i>=0; i--) printf("%.4d",v[i]);
  }
```

```cpp
  friend std::ostream& operator << (std::ostream& out,
      const Bigint &a) {
    if (a.empty()) { out << "0"; return out; }
    if (a.s == -1) out << "-";
    out << a.back();
    for (int i=a.len()-2; i>=0; i--) {
      char str[10];
      snprintf(str, 5, "%.4d", a.v[i]);
      out << str;
    }
    return out;
  }
  int cp3(const Bigint &b)const {
    if (s != b.s) return s > b.s ? 1 : -1;
    if (s == -1) return -(-*this).cp3(-b);
    if (len() != b.len()) return len()>b.len()?1:-1;
    for (int i=len()-1; i>=0; i--)
      if (v[i]!=b.v[i]) return v[i]>b.v[i]?1:-1;
    return 0;
  }
  bool operator < (const Bigint &b)const{ return cp3(b)
    ==-1; }
  bool operator <= (const Bigint &b)const{ return cp3(b
    )<=0; }
  bool operator >= (const Bigint &b)const{ return cp3(b
    )>=0; }
  bool operator == (const Bigint &b)const{ return cp3(b
    )==0; }
  bool operator != (const Bigint &b)const{ return cp3(b
    )!=0; }
  bool operator > (const Bigint &b)const{ return cp3(b)
    ==1; }
  Bigint operator - () const {
    Bigint r = (*this);
    r.s = -r.s;
    return r;
  }
  Bigint operator + (const Bigint &b) const {
    if (s == -1) return -(-(*this)+(-b));
    if (b.s == -1) return (*this)-(-b);
    Bigint r;
    int nl = max(len(), b.len());
    r.resize(nl + 1);
    for (int i=0; i<nl; i++) {
      if (i < len()) r.v[i] += v[i];
      if (i < b.len()) r.v[i] += b.v[i];
      if(r.v[i] >= BIGMOD) {
        r.v[i+1] += r.v[i] / BIGMOD;
        r.v[i] %= BIGMOD;
      }
    }
    r.n();
    return r;
  }
  Bigint operator - (const Bigint &b) const {
    if (s == -1) return -(-(*this)-(-b));
    if (b.s == -1) return (*this)+(-b);
    if ((*this) < b) return -(b-(*this));
    Bigint r;
    r.resize(len());
    for (int i=0; i<len(); i++) {
      r.v[i] += v[i];
      if (i < b.len()) r.v[i] -= b.v[i];
      if (r.v[i] < 0) {
        r.v[i] += BIGMOD;
        r.v[i+1]--;
      }
    }
    r.n();
    return r;
  }
  Bigint operator * (const Bigint &b) {
    Bigint r;
    r.resize(len() + b.len() + 1);
    r.s = s * b.s;
    for (int i=0; i<len(); i++) {
      for (int j=0; j<b.len(); j++) {
        r.v[i+j] += v[i] * b.v[j];
        if(r.v[i+j] >= BIGMOD) {
          r.v[i+j+1] += r.v[i+j] / BIGMOD;
          r.v[i+j] %= BIGMOD;
        }
      }
```

```
          }
        }
        r.n();
        return r;
      }
    Bigint operator / (const Bigint &b) {
        Bigint r;
        r.resize(max(1, len()-b.len()+1));
        int oriS = s;
        Bigint b2 = b; // b2 = abs(b)
        s = b2.s = r.s = 1;
        for (int i=r.len()-1; i>=0; i--) {
          int d=0, u=BIGMOD-1;
          while(d<u) {
            int m = (d+u+1)>>1;
            r.v[i] = m;
            if((r*b2) > (*this)) u = m-1;
            else d = m;
          }
          r.v[i] = d;
        }
        s = oriS;
        r.s = s * b.s;
        r.n();
        return r;
      }
    Bigint operator % (const Bigint &b) {
        return (*this)-(*this)/b*b;
      }
};
```

Random

```
inline int ran(){
  static int x = 20167122;
  return x = (x * 0xdefaced + 1) & INT_MAX;
}
```

Theorem

```
/*
Lucas's Theorem:
  For non-negative integer n,m and prime P,
  C(m,n) mod P = C(m/M,n/M) * C(m%M,n%M) mod P
  = mult_i ( C(m_i,n_i) )
  where m_i is the i-th digit of m in base P.
-----------------------------------------------------
Pick's Theorem
  A = i + b/2 - 1
-----------------------------------------------------
Kirchhoff's theorem
  A_{ii} = deg(i), A_{ij} = (i,j) \in E ? -1 : 0
  Deleting any one row, one column, and cal the det(A)
*/
```

Miller Rabin

```
typedef long long LL;

inline LL bin_mul(LL a, LL n,const LL& MOD){
  LL re=0;
  while (n>0){
    if (n&1) re += a;
    a += a; if (a>=MOD) a-=MOD;
    n>>=1;
  }
  return re%MOD;
}

inline LL bin_pow(LL a, LL n,const LL& MOD){
  LL re=1;
  while (n>0){
    if (n&1) re = bin_mul(re,a,MOD);
    a = bin_mul(a,a,MOD);
    n>>=1;
  }
```

```
  return re;
}

bool is_prime(LL n){
  //static LL sprp[3] = { 2LL, 7LL, 61LL};
  static LL sprp[7] = { 2LL, 325LL, 9375LL,
    28178LL, 450775LL, 9780504LL,
    1795265022LL };
  if (n==1 || (n&1)==0 ) return n==2;
  int u=n-1, t=0;
  while ( (u&1)==0 ) u>>=1, t++;
  for (int i=0; i<3; i++){
    LL x = bin_pow( sprp[i]%n, u, n);
    if (x==0 || x==1 || x==n-1)continue;

    for (int j=1; j<t; j++){
      x=x*x%n;
      if (x==1 || x==n-1)break;
    }
    if (x==n-1)continue;
    return 0;
  }
  return 1;
}
```

ax+by=gcd(a,b)

```
typedef pair<int, int> pii;
pii extgcd(int a, int b){
  if(b == 0) return make_pair(1, 0);
  else{
    int p = a / b;
    pii q = extgcd(b, a % b);
    return make_pair(q.second, q.first - q.second * p);
  }
}
```

FFT

```
const double pi = atan(1.0)*4;
struct Complex {
    double x,y;
    Complex(double _x=0,double _y=0)
        :x(_x),y(_y) {}
    Complex operator + (Complex &tt) { return Complex(x
        +tt.x,y+tt.y); }
    Complex operator - (Complex &tt) { return Complex(x
        -tt.x,y-tt.y); }
    Complex operator * (Complex &tt) { return Complex(x
        *tt.x-y*tt.y,x*tt.y+y*tt.x); }
};
void fft(Complex *a, int n, int rev) {
    // n是大于等于相乘的两个数组长度的2的幂次
    // 从0开始表示长度，对a进行操作
    // rev==1进行DFT，==-1进行IDFT
    for (int i = 1,j = 0; i < n; ++ i) {
        for (int k = n>>1; k > (j^=k); k >>= 1);
        if (i<j) std::swap(a[i],a[j]);
    }
    for (int m = 2; m <= n; m <<= 1) {
        Complex wm(cos(2*pi*rev/m),sin(2*pi*rev/m));
        for (int i = 0; i < n; i += m) {
            Complex w(1.0,0.0);
            for (int j = i; j < i+m/2; ++ j) {
                Complex t = w*a[j+m/2];
                a[j+m/2] = a[j] - t;
                a[j] = a[j] + t;
                w = w * wm;
            }
        }
    }
    if (rev==-1) {
        for (int i = 0; i < n; ++ i) a[i].x /= n,a[i].y
            /= n;
    }
}
```

FWHT

```cpp
// FWHT template

const int MAXN = 1<<20;

void FWHT(int a[], int l=0, int r=MAXN-1){
  if (l==r)return;

  int mid = (l+r)>>1+1, n = r-l+1;
  FWHT(a,l,mid-1);
  FWHT(a,mid,r);

  for (int i=0; i<(n>>1); i++){
    int a1=a[l+i], a2=a[mid+i];
    a[l+i] = a1+a2;
    a[mid+i] = a1-a2;
  }
}
```

Hash

```cpp
typedef long long LL;
LL X=7122;
LL P1=712271227;
LL P2=179433857;
LL P3=179434999;

struct HASH{
    LL a, b, c;
    HASH(LL a=0, LL b=0, LL c=0):a(a),b(b),c(c){ }
    HASH operator + (HASH B){
        return HASH((a+B.a)%P1,(b+B.b)%P2,(c+B.c)%P3);
    }
  HASH operator + (LL B){
    return (*this)+HASH(B,B,B);
  }
  HASH operator * (LL B){
    return HASH(a*B%P1,a*B%P2,a*B%P3);
  }
    bool operator < (const HASH &B)const{
        if (a!=B.a)return a<B.a;
        if (b!=B.b)return b<B.b;
        return c<B.c;
    }
    void up(){ (*this) = (*this)*X; }
};

int main(){
}
```

GaussElimination

```cpp
// by bcw_codebook

const int MAXN = 300;
const double EPS = 1e-8;

int n;
double A[MAXN][MAXN];

void Gauss() {
  for(int i = 0; i < n; i++) {
    bool ok = 0;
    for(int j = i; j < n; j++) {
      if(fabs(A[j][i]) > EPS) {
        swap(A[j], A[i]);
        ok = 1;
        break;
      }
    }
    if(!ok) continue;

    double fs = A[i][i];
    for(int j = i+1; j < n; j++) {
      double r = A[j][i] / fs;
      for(int k = i; k < n; k++) {
        A[j][k] -= A[i][k] * r;
      }
    }
  }
}
```

Inverse

```cpp
int inverse[100000];
void invTable(int b, int p) {
  inverse[1] = 1;
  for( int i = 2; i <= b; i++ ) {
    inverse[i] = (long long)inverse[p%i] * (p-p/i) % p;
  }
}

int inv(int b, int p) {
  return b == 1 ? 1 : ((long long)inv(p % b, p) * (p-p/
    b) % p);
}
```

IterSet

```cpp
// get all subset in set S

for (int i = S; i ; i = (i-1) & S ) {


}
```

SG

Sprague-Grundy

1. 雙人、回合制
2. 資訊完全公開
3. 無隨機因素
4. 可在有限步內結束
5. 沒有和局
6. 雙方可採取的行動相同

SG(S) 的值為 0：後手(P)必勝
不為 0：先手(N)必勝

```python
int mex(set S) {
  // find the min number >= 0 that not in the S
  // e.g. S = {0, 1, 3, 4} mex(S) = 2
}

state = []
int SG(A) {
  if (A not in state) {
    S = sub_states(A)
    if( len(S) > 1 ) state[A] = reduce(operator.xor, [
      SG(B) for B in S])
    else state[A] = mex(set(SG(B) for B in next_states(
      A)))
  }
  return state[A]
}
```

Graph

Strongly Connected Component(SCC)

```cpp
#define MXN 100005
#define PB push_back
#define FZ(s) memset(s,0,sizeof(s))

struct Scc{
int n, nScc, vst[MXN], bln[MXN];
```

```cpp
vector<int> E[MXN], rE[MXN], vec;
void init(int _n){
  n = _n;
  for (int i=0; i<MXN; i++){
    E[i].clear();
    rE[i].clear();
  }
}
void add_edge(int u, int v){
  E[u].PB(v);
  rE[v].PB(u);
}
void DFS(int u){
  vst[u]=1;
  for (auto v : E[u])
    if (!vst[v]) DFS(v);
  vec.PB(u);
}
void rDFS(int u){
  vst[u] = 1;
  bln[u] = nScc;
  for (auto v : rE[u])
    if (!vst[v]) rDFS(v);
}
void solve(){
  nScc = 0;
  vec.clear();
  FZ(vst);
  for (int i=0; i<n; i++)
    if (!vst[i]) DFS(i);
  reverse(vec.begin(),vec.end());
  FZ(vst);
  for (auto v : vec){
    if (!vst[v]){
      rDFS(v);
      nScc++;
    }
  }
}
};
```

Euler Circuit

```cpp
//CF 723E
#include <bits/stdc++.h>
using namespace std;

const int MAXN = 300;

struct EDGE{
    int u ,v ;
    int type;
};

int n, m, deg[MAXN];
vector <EDGE> edges;
vector<int> G[MAXN];
bool vis[MAXN*MAXN];
bool alive[MAXN][MAXN];
bool visN[MAXN];
vector<int> ans;

void add_edge(int u, int v, int type=0){
    edges.push_back( EDGE{u,v,type} );
    edges.push_back( EDGE{v,u,type} );
    G[u].push_back( edges.size()-2 );
    G[v].push_back( edges.size()-1 );
    deg[u]++, deg[v]++;
    alive[u][v]=alive[v][u]|=type^1;
}

void input(){
    memset(visN,0,sizeof(visN));
    memset(vis,0,sizeof(vis));
    memset(alive,0,sizeof(alive));
    memset(deg,0,sizeof(deg));
    edges.clear();
    ans.clear();
    for (int i=0; i<MAXN; i++)G[i].clear();
```

```cpp
    scanf("%d%d",&n ,&m);
    for (int i=0, u, v; i<m; i++){
        scanf("%d%d", &u, &v);
        add_edge(u,v);
    }
}

void add_Graph(){
    vector<int> tmp;
    for (int i=1; i<=n; i++)if (deg[i]%2==1){
        tmp.push_back(i);
    }
    printf("%d\n",n-tmp.size());
    for (int i=0; i<tmp.size(); i+=2){
        add_edge(tmp[i],tmp[i+1],1);
    }
}

void dfs(int u){
    visN[u]=1;
    for (int i=0; i<G[u].size(); i++)if (!vis[ G[u][i
        ]>>1 ]){
        EDGE &e = edges[ G[u][i] ];
        int v = e.v;
        vis[ G[u][i]>>1 ]=1;
        dfs(v);
    }
    ans.push_back(u);
}

int main(){
    int T; scanf("%d",&T);
    while (T--){
        input();
        add_Graph();
        for (int i=1; i<=n; i++)if (!visN[i]){
            dfs(i);
            for (int j=0 ;j<ans.size()-1; j++){
                int u = ans[j], v=ans[j+1];
                if (alive[u][v]){
                    alive[u][v]=alive[v][u]=0;
                    printf("%d %d\n",u ,v);
                }
            }
            ans.clear();
        }
    }
}
```

Hungarian

```cpp
vector<int> G[MAXN];
int n;
int match[MAXN]; // Matching Result
int visit[MAXN];

bool dfs(int u) {
    for ( auto v:G[u] ) {
        if (!visit[v]) {
            visit[v] = true;
            if (match[v] == -1 || dfs(match[v])) {
                match[v] = u;
                match[u] = v;
                return true;
            }
        }
    }
    return false;
}

int hungarian() {
    int res = 0;
    memset(match, -1, sizeof(match));
    for (int i = 0; i < n; i++) {
        if (match[i] == -1) {
            memset(visit, 0, sizeof(visit));
            if (dfs(i)) res += 1;
        }
    }
```

```
        return res;
}
```

Maximum Clique

```cpp
const int MAXN = 105;
int best;
int m ,n;
int num[MAXN];
// int x[MAXN];
int path[MAXN];
int g[MAXN][MAXN];

bool dfs( int *adj, int total, int cnt ){
    int i, j, k;
    int t[MAXN];
    if( total == 0 ){
        if( best < cnt ){
            // for( i = 0; i < cnt; i++) path[i] = x[i
                ];
            best = cnt; return true;
        }
        return false;
    }
    for( i = 0; i < total; i++){
        if( cnt+(total-i) <= best ) return false;
        if( cnt+num[adj[i]] <= best ) return false;
        // x[cnt] = adj[i];
        for( k = 0, j = i+1; j < total; j++ )
            if( g[ adj[i] ][ adj[j] ] )
                t[ k++ ] = adj[j];
                if( dfs( t, k, cnt+1 ) ) return true;
    } return false;
}
int MaximumClique(){
    int i, j, k;
    int adj[MAXN];
    if( n <= 0 ) return 0;
    best = 0;
    for( i = n-1; i >= 0; i-- ){
        // x[0] = i;
        for( k = 0, j = i+1; j < n; j++ )
            if( g[i][j] ) adj[k++] = j;
        dfs( adj, k, 1 );
        num[i] = best;
    }
    return best;
}
```

Tarjan

```cpp
int n;
vector<int> G[MAXN];
stack<int> stk;
int dfn[MAXN], low[MAXN];
bool ins[MAXN];
int scc[MAXN], scn, count;

void tarjan(int u){
  dfn[u] = low[u] = ++count;
  stk.push(u);
  ins[u] = true;

  for(auto v:G[u]){
    if(!dfn[v]){
      tarjan(v);
      low[u] = min(low[u], low[v]);
    }else if(ins[v]){
      low[u] = min(low[u], dfn[v]);
    }
  }

  if(dfn[u] == low[u]){
    int v;
    do {
      v = stk.top();
      stk.pop();
      scc[v] = scn;
```

```cpp
      ins[v] = false;
    } while(v != u);
    scn++;
  }
}

void GetSCC(){
  count = scn = 0;
  for(int i = 0 ; i < n ; i++ ){
    if(!dfn[i]) tarjan(i);
  }
}
```

一般圖匹配

```cpp
#define MAXN 505
vector<int>g[MAXN];//用vector存圖
int pa[MAXN],match[MAXN],st[MAXN],S[MAXN],vis[MAXN];
int t,n;
inline int lca(int u,int v){//找花的花托
  for(++t;;swap(u,v)){
    if(u==0)continue;
    if(vis[u]==t)return u;
    vis[u]=t;//這種方法可以不用清空vis陣列
    u=st[pa[match[u]]];
  }
}
#define qpush(u) q.push(u),S[u]=0
inline void flower(int u,int v,int l,queue<int> &q){
  while(st[u]!=l){
    pa[u]=v;//所有未匹配邊的pa都是雙向的
    if(S[v=match[u]]==1)qpush(v);//所有奇點變偶點
    st[u]=st[v]=l,u=pa[v];
  }
}
inline bool bfs(int u){
  for(int i=1;i<=n;++i)st[i]=i;//st[i]表示第i個點的集合
  memset(S+1,-1,sizeof(int)*n);//-1:沒走過 0:偶點 1:奇
      點
  queue<int>q;qpush(u);
  while(q.size()){
    u=q.front(),q.pop();
    for(size_t i=0;i<g[u].size();++i){
      int v=g[u][i];
      if(S[v]==-1){
        pa[v]=u,S[v]=1;
        if(!match[v]){//有增廣路直接擴充
          for(int lst;u;v=lst,u=pa[v])
            lst=match[u],match[u]=v,match[v]=u;
          return 1;
        }
        qpush(match[v]);
      }else if(!S[v]&&st[v]!=st[u]){
        int l=lca(st[v],st[u]);//遇到花，做花的處理
        flower(v,u,l,q),flower(u,v,l,q);
      }
    }
  }
  return 0;
}
inline int blossom(){
  memset(pa+1,0,sizeof(int)*n);
  memset(match+1,0,sizeof(int)*n);
  int ans=0;
  for(int i=1;i<=n;++i)
    if(!match[i]&&bfs(i))++ans;
  return ans;
}

int main(){
  int T, m; cin >> T;

  while ( cin >> n >> m  ){
    for (int i=1; i<=n; i++) g[i].clear();
    for (int i=1, u, v; i<=m; i++){
      cin >> u >> v;
      g[u].push_back(v);
      g[v].push_back(u);
    }
```

```
      cout << blossom() << endl;
    }
}
```

LCA

```
//lv紀錄深度
//father[多少冪次][誰]
//已經建好每個人的父親是誰 (father[0][i]已經建好)
//已經建好深度 (lv[i]已經建好)
void makePP(){
  for(int i = 1; i < 20; i++){
    for(int j = 2; j <= n; j++){
      father[i][j]=father[i-1][ father[i-1][j] ];
    }
  }
}
int find(int a, int b){
  if(lv[a] < lv[b]) swap(a,b);
  int need = lv[a] - lv[b];
  for(int i = 0; need!=0; i++){
    if(need&1) a=father[i][a];
    need >>= 1;
  }
  for(int i = 19 ;i >= 0 ;i--){
    if(father[i][a] != father[i][b]){
      a=father[i][a];
      b=father[i][b];
    }
  }
  return a!=b?father[0][a] : a;
}
```

Data Structure

Disjoint Set

```
struct DisjointSet{
    int n, fa[MAXN];

    void init(int size) {
        for (int i = 0; i <= size; i++) {
            fa[i] = i;
        }
    }

    void find(int x) {
        return fa[x] == x ? x : find(fa[x]);
    }

    void unite(int x, int y) {
        p[find(x)] = find(y);
    }

} djs;
```

Sparse Table

```
const int MAXN = 200005;
const int lgN = 20;

struct SP{ //sparse table
  int Sp[MAXN][lgN];
  function<int(int,int)> opt;
  void build(int n, int *a){ // 0 base
    for (int i=0 ;i<n; i++) Sp[i][0]=a[i];

    for (int h=1; h<lgN; h++){
      int len = 1<<(h-1), i=0;
      for (; i+len<n; i++)
        Sp[i][h] = opt( Sp[i][h-1] , Sp[i+len][h-1] );
      for (; i<n; i++)
        Sp[i][h] = Sp[i][h-1];
    }
  }
```

```
  }
  int query(int l, int r){
    int h = __lg(r-l+1);
    int len = 1<<h;
    return opt( Sp[l][h] , Sp[r-len+1][h] );
  }
};
```

Treap

```
#include<bits/stdc++.h>
using namespace std;
template<class T,unsigned seed>class treap{
  public:
    struct node{
      T data;
      int size;
      node *l,*r;
      node(T d){
        size=1;
        data=d;
        l=r=NULL;
      }
      inline void up(){
        size=1;
        if(l)size+=l->size;
        if(r)size+=r->size;
      }
      inline void down(){
      }
    }*root;
    inline int size(node *p){return p?p->size:0;}
    inline bool ran(node *a,node *b){
      static unsigned x=seed;
      x=0xdefaced*x+1;
      unsigned all=size(a)+size(b);
      return (x%all+all)%all<size(a);
    }
    void clear(node *&p){
      if(p)clear(p->l),clear(p->r),delete p,p=NULL;
    }
    ~treap(){clear(root);}
    void split(node *o,node *&a,node *&b,int k){
      if(!k)a=NULL,b=o;
      else if(size(o)==k)a=o,b=NULL;
      else{
        o->down();
        if(k<=size(o->l)){
          b=o;
          split(o->l,a,b->l,k);
          b->up();
        }else{
          a=o;
          split(o->r,a->r,b,k-size(o->l)-1);
          a->up();
        }
      }
    }
    void merge(node *&o,node *a,node *b){
      if(!a||!b)o=a?a:b;
      else{
        if(ran(a,b)){
          a->down();
          o=a;
          merge(o->r,a->r,b);
        }else{
          b->down();
          o=b;
          merge(o->l,a,b->l);
        }
        o->up();
      }
    }
    void build(node *&p,int l,int r,T *s){
      if(l>r)return;
      int mid=(l+r)>>1;
      p=new node(s[mid]);
      build(p->l,l,mid-1,s);
      build(p->r,mid+1,r,s);
      p->up();
```

```
        }
        inline int rank(T data){
            node *p=root;
            int cnt=0;
            while(p){
                if(data<=p->data)p=p->l;
                else cnt+=size(p->l)+1,p=p->r;
            }
            return cnt;
        }
        inline void insert(node *&p,T data,int k){
            node *a,*b,*now;
            split(p,a,b,k);
            now=new node(data);
            merge(a,a,now);
            merge(p,a,b);
        }
};
treap<int ,20141223>bst;
int n,m,a,b;
int main(){
    //當成二分查找樹用
    while(~scanf("%d",&a))bst.insert(bst.root,a,bst.rank(
        a));
    while(~scanf("%d",&a))printf("%d\n",bst.rank(a));
    bst.clear(bst.root);
    return 0;
}
```

String

KMP

```
template<typename T>
void build_KMP(int n, T *s, int *f){ // 1 base
    f[0]=-1, f[1]=0;
    for (int i=2; i<=n; i++){
        int w = f[i-1];
        while (w>=0 && s[w+1]!=s[i])w = f[w];
        f[i]=w+1;
    }
}

template<typename T>
int KMP(int n, T *a, int m, T *b){
    build_KMP(n,b,f);
    int ans=0;

    for (int i=1, w=0; i<=n; i++){
        while ( w>=0 && b[w+1]!=a[i] )w = f[w];
        w++;
        if (w==m){
            ans++;
            w=f[w];
        }
    }
    return ans;
}
```

AC

```
// by bcw_codebook
struct ACautomata{
    struct Node{
        int cnt,dp;
        Node *go[26], *fail;
        Node (){
            cnt = 0;
            dp = -1;
            memset(go,0,sizeof(go));
            fail = 0;
        }
    };

    Node *root, pool[1048576];
    int nMem;
```

```
    Node* new_Node(){
        pool[nMem] = Node();
        return &pool[nMem++];
    }
    void init(){
        nMem = 0;
        root = new_Node();
    }
    void add(const string &str){
        insert(root,str,0);
    }
    void insert(Node *cur, const string &str, int pos){
        if (pos >= (int)str.size()){
            cur->cnt++;
            return;
        }
        int c = str[pos]-'a';
        if (cur->go[c] == 0){
            cur->go[c] = new_Node();
        }
        insert(cur->go[c],str,pos+1);
    }
    void make_fail(){
        queue<Node*> que;
        que.push(root);
        while (!que.empty()){
            Node* fr=que.front();
            que.pop();
            for (int i=0; i<26; i++){
                if (fr->go[i]){
                    Node *ptr = fr->fail;
                    while (ptr && !ptr->go[i]) ptr = ptr->fail;
                    if (!ptr) fr->go[i]->fail = root;
                    else fr->go[i]->fail = ptr->go[i];
                    que.push(fr->go[i]);
                }
            }
        }
    }
};
```

Z-value

```
z[0] = 0;
for ( int bst = 0, i = 1; i < len ; i++ ) {
    if ( z[bst] + bst <= i ) z[i] = 0;
    else z[i] = min(z[i - bst], z[bst] + bst - i);
    while ( str[i + z[i]] == str[z[i]] ) z[i]++;
    if ( i + z[i] > bst + z[bst] ) bst = i;
}
```

Suffix Array

```
const int MAX = 1020304;
int ct[MAX], he[MAX], rk[MAX];
int sa[MAX], tsa[MAX], tp[MAX][2];
void suffix_array(char *ip){
    int len = strlen(ip);
    int alp = 256;
    memset(ct, 0, sizeof(ct));
    for(int i=0;i<len;i++) ct[ip[i]+1]++;
    for(int i=1;i<alp;i++) ct[i]+=ct[i-1];
    for(int i=0;i<len;i++) rk[i]=ct[ip[i]];
    for(int i=1;i<len;i*=2){
        for(int j=0;j<len;j++){
            if(j+i>=len) tp[j][1]=0;
            else tp[j][1]=rk[j+i]+1;
            tp[j][0]=rk[j];
        }
        memset(ct, 0, sizeof(ct));
        for(int j=0;j<len;j++) ct[tp[j][1]+1]++;
        for(int j=1;j<len+2;j++) ct[j]+=ct[j-1];
        for(int j=0;j<len;j++) tsa[ct[tp[j][1]]++]=j;
        memset(ct, 0, sizeof(ct));
        for(int j=0;j<len;j++) ct[tp[j][0]+1]++;
        for(int j=1;j<len+1;j++) ct[j]+=ct[j-1];
        for(int j=0;j<len;j++)
```

```
      sa[ct[tp[tsa[j]][0]]++]=tsa[j];
    rk[sa[0]]=0;
    for(int j=1;j<len;j++){
      if( tp[sa[j]][0] == tp[sa[j-1]][0] &&
        tp[sa[j]][1] == tp[sa[j-1]][1] )
        rk[sa[j]] = rk[sa[j-1]];
      else
        rk[sa[j]] = j;
    }
  }
  for(int i=0,h=0;i<len;i++){
    if(rk[i]==0) h=0;
    else{
      int j=sa[rk[i]-1];
      h=max(0,h-1);
      for(;ip[i+h]==ip[j+h];h++);
    }
    he[rk[i]]=h;
  }
}
```

Suffix Automaton

```
// par : fail link
// val : a topological order ( useful for DP )
// go[x] : automata edge ( x is integer in [0,26) )

struct SAM{
  struct State{
    int par, go[26], val;
    State () : par(0), val(0){ FZ(go); }
    State (int _val) : par(0), val(_val){ FZ(go); }
  };
  vector<State> vec;
  int root, tail;

  void init(int arr[], int len){
    vec.resize(2);
    vec[0] = vec[1] = State(0);
    root = tail = 1;
    for (int i=0; i<len; i++)
      extend(arr[i]);
  }
  void extend(int w){
    int p = tail, np = vec.size();
    vec.PB(State(vec[p].val+1));
    for ( ; p && vec[p].go[w]==0; p=vec[p].par)
      vec[p].go[w] = np;
    if (p == 0){
      vec[np].par = root;
    } else {
      if (vec[vec[p].go[w]].val == vec[p].val+1){
        vec[np].par = vec[p].go[w];
      } else {
        int q = vec[p].go[w], r = vec.size();
        vec.PB(vec[q]);
        vec[r].val = vec[p].val+1;
        vec[q].par = vec[np].par = r;
        for ( ; p && vec[p].go[w] == q; p=vec[p].par)
          vec[p].go[w] = r;
      }
    }
    tail = np;
  }
};
```

Dark Code

輸入優化

```
#include <stdio.h>

char getc(){
  static const int bufsize = 1<<16;
  static char B[bufsize], *S=B, *T=B;
  return (S==T&&(T=(S=B)+fread(B,1,bufsize,stdin),S==T)
    ?0:*S++);
```

```
}

template <class T>
bool input(T& a){
  a=(T)0;
  register char p;
  while ((p = getc()) < '-')
    if (p==0 || p==EOF) return false;
  if (p == '-')
    while ((p = getc()) >= '0') a = a*10 - (p^'0');
  else {
    a = p ^ '0';
    while ((p = getc()) >= '0') a = a*10 + (p^'0');
  }
  return true;
}

template <class T, class... U>
bool input(T& a, U&... b){
  if (!input(a)) return false;
  return input(b...);
}
```

Search

Others

數位統計

```
int dfs(int pos, int state1, int state2 ....., bool
    limit, bool zero) {
    if ( pos == -1 ) return 是否符合條件;
    int &ret = dp[pos][state1][state2][....];
    if ( ret != -1 && !limit ) return ret;
    int ans = 0;
    int upper = limit ? digit[pos] : 9;
    for ( int i = 0 ; i <= upper ; i++ ) {
        ans += dfs(pos - 1, new_state1, new_state2,
            limit & ( i == upper), ( i == 0) && zero);
    }
    if ( !limit ) ret = ans;
    return ans;
}

int solve(int n) {
    int it = 0;
    for ( ; n ; n /= 10 ) digit[it++] = n % 10;
    return dfs(it - 1, 0, 0, 1, 1);
}
```

STL

```
// algorithm
random_shuffle(a,a+n);
next_permutation(a,a+n); // need sort
nth_element (a, a+k, a+n); // kth
*min_element(a,a+n);
*unique(a,a+n); // need sort
stable_sort(a,a+n); // merge sort

// bitset (s[0] is right most)
operator[] //
count() // count number of 1
set() // all to 1
set(k) //   s[k] to 1
set(k,0) // s[k] to 0
flip()  // all flip
flip(k) // s[k] flip
to_ulong()
to_string()
```

Persistence