Contents

Basic

/.bashrc

```
tabs -4
```

/.vimrc

```
set nu    "行號"
set tabstop=4 "tab寬度"
set autoindent
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 <CR>
nmap <F4> :! date > %<.pt; cat -n % > %<.pt; lpr %<.pt
    <CR>
nmap <F9> :! clear ; g++ -std=c++11 -Wall -O2  % -o %<.
    out; ./%<.out < %<.in <CR>
nmap <F10> :! clear ; g++ -std=c++11 -Wall -O2  % -o
    %<.out; ./%<.out <CR>
```

Faster cin

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

int main(){
    ios_base::sync_with_stdio(false);
    cin.tie(0);
}
```

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(); */ }
```

```cpp
  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]);
  }
  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();
```

```cpp
    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

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

Mathmatics

Miller Rabin

```cpp
typedef long long LL;

LL bin_pow(LL a, LL n, LL MOD){
  LL re=1;
  while (n>0){
    if (n&1)re = re*a %MOD;
    a = 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<7; 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;
    }
}
```

Hash

```
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

```
// 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

```
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

```
// get all subset in set S

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


}
```

LinearPrime

```
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;
        }
    }
}
```

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

```
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]
}
```

Geometry

2D Point Template

```
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{
        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

```
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

```
#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;
        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];
```

```cpp
            //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(,);
```

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;
```

```
|}


  KM


// From https://github.com/bobogei81123/bcw_codebook/
    blob/master/codes/Graph/Matching/Kuhn_Munkres.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;


  min cost max flow


// from: https://github.com/bobogei81123/bcw_codebook/
    blob/master/codes/Graph/Flow/CostFlow.cpp
typedef pair<long long, long long> pll;
struct CostFlow {
  static const int MXN = 205;
  static const long long INF = 102938475610293847LL;
  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;


## Graph


## Strongly Connected Component(SCC)


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

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

```
//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();

    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

```
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

```
const int MAXN = 105;
int best;
```

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

void GetSCC(){
  count = scn = 0;
  for(int i = 0 ; i < n ; i++ ){
```

```cpp
    if(!dfn[i]) tarjan(i);
  }
}
```

LCA

```cpp
//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

```cpp
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

```cpp
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;
```

```cpp
  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]);
        }
      }
    }
  }
};
```

```cpp
  }
  return true;
}

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

Search

Others

Persistence

Z-value

```cpp
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;
}
```

Dark Code

輸入優化

```cpp
#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');
```