ICPC TEMPLATE

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目录

1 一切的开始

1.1 宏定义

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```cpp
#include <bits/stdc++.h>
using namespace std;
#define rep(i,a,n) for (int i=a;i<n;i++)//注意范围[a.n)
#define per(i,a,n) for (int i=n-1;i>=a;i--)//注意范围[a.n-1]
#define pb push_back
#define mp make_pair
#define all(x) (x).begin(),(x).end()
#define fi first
#define se second
#define SZ(x) ((int)(x).size())
typedef vector<int> VI;
typedef long long ll;
typedef pair<int,int> PII;
mt19937 mrand(random_device{}());
const ll mod=1000000007;
int rnd(int x) { return mrand() % x;}
ll powmod(ll a,ll b) {ll res=1;a%=mod; assert(b>=0);
    for(;b;b>>=1){if(b&1)res=res*a%mod;a=a*a%mod;}return res;}
ll gcd(ll a,ll b) { return b?gcd(b,a%b):a;}
// --------------------------------------------------------------------------------
```

- CMakeLists.txt (for CLion)

```
set(CMAKE_CXX_FLAGS "${CMAKE_CXX_FLAGS} -O2 -Dzerol -Wall")
```

- HDU Assert Patch

```
1  #ifdef ONLINE_JUDGE
2  #define assert(condition) if (!(condition)) { int x = 1, y = 0; cout << x / y <<
       endl; }
3  #endif
```

1.2   快速读

```
1  inline char nc() {
2      static char buf[100000], *p1 = buf, *p2 = buf;
3      return p1 == p2 && (p2 = (p1 = buf) + fread(buf, 1, 100000, stdin), p1 == p2) ?
           EOF : *p1++;
4  }
5  template <typename T>
6  bool rn(T& v) {
7      static char ch;
8      while (ch != EOF && !isdigit(ch)) ch = nc();
9      if (ch == EOF) return false;
10     for (v = 0; isdigit(ch); ch = nc())
11         v = v * 10 + ch - '0';
12     return true;
13 }
14
15 template <typename T>
16 void o(T p) {
17     static int stk[70], tp;
18     if (p == 0) { putchar('0'); return; }
19     if (p < 0) { p = -p; putchar('-'); }
20     while (p) stk[++tp] = p % 10, p /= 10;
21     while (tp) putchar(stk[tp--] + '0');
22 }
```

- 需要初始化
- 需要一次读入
- 不支持负数

```cpp
const int MAXS = 100 * 1024 * 1024;
char buf[MAXS];
template<typename T>
inline bool read(T& x) {
    static char* p = buf;
    x = 0;
    while (*p && !isdigit(*p)) ++p;
    if (!*p) return false;
    while (isdigit(*p)) x = x * 10 + *p++ - 48;
    return true;
}

fread(buf, 1, MAXS, stdin);
```

1.3 对拍

```bash
#!/usr/bin/env bash
g++ -o r main.cpp -O2 -std=c++11
g++ -o std std.cpp -O2 -std=c++11
while true; do
    python gen.py > in
    ./std < in > stdout
    ./r < in > out
    if test $? -ne 0; then
        exit 0
    fi
    if diff stdout out; then
        printf "AC\n"
    else
        printf "GG\n"
        exit 0
    fi
done
```

- 快速编译运行

```bash
#!/bin/bash
g++ $1.cpp -o $1 -O2 -std=c++14 -Wall -Dzerol -g
if $? -eq 0; then
    ./$1
fi
```

2 数据结构

2.1 BIT

```cpp
struct Bit
{
    vector<int> a;
    int sz;
    void init(int n)
    {
        sz=n+5;
        for(int i=1;i<=n+5;i++)
            a.push_back(0);
    }
    int lowbit(int x)
    {
        return x&(-x);
    }
    int query(int x)
    {
        int ans = 0;
        for(;x;x-=lowbit(x))ans+=a[x];
        return ans;
    }
    void update(int x,int v)
    {
        for(;x<sz;x+=lowbit(x))
            a[x]+=v;
    }
```

```
26  }bit;
```

3   图论

3.1   最短路

3.1.1   floyd

```
1  for (int k = 1; k <= n; k++) {
2    for (int i = 1; i <= n; i++) {
3      for (int j = 1; j <= n; j++) {
4        f[i][j] = min(f[i][j], f[i][k] + f[k][j]);
5      }
6    }
7  }
```

- 找最小环

```
1  int val[maxn + 1][maxn + 1]; // 原图的邻接矩阵
2  int floyd(const int &n) {
3    static int dis[maxn + 1][maxn + 1]; // 最短路矩阵
4    for (int i = 1; i <= n; ++i)
5      for (int j = 1; j <= n; ++j) dis[i][j] = val[i][j]; // 初始化最短路矩阵
6    int ans = inf;
7    for (int k = 1; k <= n; ++k) {
8      for (int i = 1; i < k; ++i)
9        for (int j = 1; j < i; ++j)
10         ans = std::min(ans, dis[i][j] + val[i][k] + val[k][j]); // 更新答案
11     for (int i = 1; i <= n; ++i)
12       for (int j = 1; j <= n; ++j)
13         dis[i][j] = std::min(
14           dis[i][j], dis[i][k] + dis[k][j]); // 正常的 floyd 更新最短路矩阵
15   }
16   return ans;
17  }
```

- 利用 floyd 的 dp 思路求解

```
int dp[maxn][maxn][maxn];
int w[maxn];
int s[maxn];
bool cmp(int a,int b)
{
    return w[a] < w[b];
}
rep(i,1,n+1)
{
    rep(j,1,n+1)
    {
      scanf("%d",&dp[i][j][0]);
       rep(k,1,n+1)
       {
           dp[i][j][k] = 1e9;
       }
     }
    s[i] = i;
}
sort(s+1,s+n+1,cmp);
rep(k,1,n+1)
{
    rep(i,1,n+1)
    {
       rep(j,1,n+1)
       {
           dp[i][j][k] = min(dp[i][j][k-1],dp[i][s[k]][k-1]+dp[s[k]][j][k-1]);
       }
    }
}
```

- 传递闭包已知一个有向图中任意两点之间是否有连边，要求判断任意两点是否连通。

```
for (int k = 1; k <= n; k++)
  for (int i = 1; i <= n; i++)
```

```
3    if (f[i][k]) f[i] = f[i] & f[k];
```

3.2 网络流

- dinic

```
1   const int maxn = 4e3+100;
2   const int maxm = 1e5+100;
3   const int inf = 0x7f7f7f7f;
4
5   typedef struct Dinic
6   {
7       typedef struct Edge
8       {
9           int u,v,w,nxt;
10      } Edge;
11      int head[maxn],hcnt;
12      int dep[maxn];
13      int cur[maxn];
14      Edge e[maxm];
15      int S,T,N;
16      void init()
17      {
18          memset(head,-1,sizeof head);
19          hcnt = 0;
20          S = T = N = 0;
21      }
22      void adde(int u,int v,int w)
23      {
24          e[hcnt].u = u,e[hcnt].v = v,e[hcnt].w = w;
25          e[hcnt].nxt = head[u];head[u] = hcnt++;
26          e[hcnt].u = v,e[hcnt].v = u,e[hcnt].w = 0;
27          e[hcnt].nxt = head[v];head[v] = hcnt++;
28      }
29      int bfs()
30      {
31          rep(i,0,N)
```

```
32          {
33              dep[i] = inf;
34          }
35          queue<int> q;
36          q.push(S); dep[S] = 0;
37          while(!q.empty())
38          {
39              int u = q.front();q.pop();
40              for(int i = head[u];~i;i = e[i].nxt)
41              {
42                  int v = e[i].v,w = e[i].w;
43                  if(w > 0 && dep[u] + 1 < dep[v])
44                  {
45                      dep[v] = dep[u] + 1;
46                      if(v == T)
47                      {
48                          return 1;
49                      }
50                      q.push(v);
51                  }
52              }
53          }
54          return dep[T] != inf;
55      }
56      int dfs(int s,int mw)
57      {
58          if(s == T) return mw;
59          for(int i = cur[s];~i;i=e[i].nxt)
60          {
61              cur[s] = i;
62              int v = e[i].v,w=e[i].w;
63              if(w <= 0 || dep[v] != dep[s] + 1)
64              {
65                  continue;
66              }
67              int cw = dfs(v,min(w,mw));
68              if(cw <= 0)
```

```
69              continue;
70          e[i].w -= cw;
71          e[i^1].w += cw;
72          return cw;
73      }
74      return 0;
75  }
76  ll dinic()
77  {
78      ll res = 0;
79      while(bfs())
80      {
81          rep(i,0,N)
82          {
83              cur[i] = head[i];
84          }
85          while(int d = dfs(S,inf))
86          {
87              res += 1ll * d;
88          }
89      }
90      return res;
91  }
92 } Dinic;
```

- MCMF1

```
1  namespace mincostflow {
2      const int INF=0x3f3f3f3f;
3      struct node {
4          int to; int cap,cost; int rev;
5          node(int t=0,int c=0,int _c=0,int n=0):
6              to(t),cap(c),cost(_c),rev(n) {};
7      }; vector<node> edge[maxn];
8      void addedge(int from,int to,int cap,int cost) {
9          edge[from].push_back(node(to,cap,cost,edge[to].size()));
10         edge[to].push_back(node(from,0,-cost,edge[from].size()-1));
```

```
11      }
12      int dis[maxn];
13      bool mark[maxn];
14      void spfa(int s,int t,int n) {
15          memset(dis+1,0x3f,n*sizeof(int));
16          memset(mark+1,0,n*sizeof(bool));
17          static int Q[maxn],ST,ED;
18          dis[s]=0; ST=ED=0; Q[ED++]=s;
19          while (ST!=ED) {
20              int v=Q[ST]; mark[v]=0;
21              if ((++ST)==maxn) ST=0;
22              for (node &e:edge[v]) {
23                  if (e.cap>0&&dis[e.to]>dis[v]+e.cost) {
24                      dis[e.to]=dis[v]+e.cost;
25                      if (!mark[e.to]) {
26                          if (ST==ED||dis[Q[ST]]<=dis[e.to]) {
27                              Q[ED]=e.to,mark[e.to]=1;
28                              if ((++ED)==maxn) ED=0;
29                          } else {
30                              if ((--ST)<0) ST+=maxn;
31                              Q[ST]=e.to,mark[e.to]=1;
32                          }
33                      }
34                  }
35              }
36          }
37      } int cur[maxn];
38      int dfs(int x,int t,int flow) {
39          if (x==t||!flow) return flow;
40          int ret=0; mark[x]=1;
41          for (int &i=cur[x];i<(int)edge[x].size();i++) {
42              node &e=edge[x][i];
43              if (!mark[e.to]&&e.cap) {
44                  if (dis[x]+e.cost==dis[e.to]) {
45                      int f=dfs(e.to,t,min(flow,e.cap));
46                      e.cap-=f; edge[e.to][e.rev].cap+=f;
47                      ret+=f; flow-=f;
```

```
48                  if (flow==0) break;
49              }
50          }
51      } mark[x]=0;
52      return ret;
53  }
54  pair<int,int> min_costflow(int s,int t,int n) {
55      int ret=0,ans=0;
56      int flow = INF;
57      while (flow) {
58          spfa(s,t,n); if (dis[t]==INF) break;
59          memset(cur+1,0,n*sizeof(int));
60          int len=dis[t],f;
61          while ((f=dfs(s,t,flow))>0)
62              ret+=f,ans+=len*f,flow-=f;
63      } return make_pair(ret,ans);//最大流，最小费用
64  }
65  void init(int n) {
66      int i; for (int i = 1; i <= n; i++) edge[i].clear();
67  }
68 }
```

- MCMF2

```
1  const int maxn = 2e4+10;
2  namespace MCMF {
3      const int inf=0x3f3f3f3f;
4      struct Edge {
5          int to; int cap,cost; int rev;
6          Edge(int t=0,int c=0,int _c=0,int n=0):
7              to(t),cap(c),cost(_c),rev(n) {};
8      };
9      vector<Edge> edge[maxn];
10     void adde(int from,int to,int cap,int cost)
11     {
12         edge[from].push_back(Edge(to,cap,cost,edge[to].size()));
13         edge[to].push_back(Edge(from,0,-cost,edge[from].size()-1));
```

```
14      }
15
16      int dis[maxn];
17      bool mark[maxn];
18
19      void spfa(int s,int t,int n)
20      {
21          memset(dis,0x3f,sizeof dis);
22          memset(mark,0,sizeof mark);
23          static int Q[maxn],ST,ED;
24          dis[s]=0; ST=ED=0; Q[ED++]=s;
25          while (ST!=ED)
26          {
27              int v=Q[ST]; mark[v]=0;
28              if ((++ST)==maxn) ST=0;
29              for (Edge &e:edge[v])
30              {
31                  if (e.cap>0&&dis[e.to]>dis[v]+e.cost)
32                  {
33                      dis[e.to]=dis[v]+e.cost;
34                      if (!mark[e.to])
35                      {
36                          if (ST==ED||dis[Q[ST]]<=dis[e.to])
37                          {
38                              Q[ED]=e.to,mark[e.to]=1;
39                              if ((++ED)==maxn) ED=0;
40                          }
41                          else
42                          {
43                              if ((--ST)<0) ST+=maxn;
44                              Q[ST]=e.to,mark[e.to]=1;
45                          }
46                      }
47                  }
48              }
49          }
50      }
```

```cpp
int cur[maxn];
int dfs(int x,int t,int flow)
{
    if (x==t||!flow) return flow;
    int ret=0; mark[x]=1;
    for (int &i=cur[x];i<(int)edge[x].size();i++)
    {
        Edge &e=edge[x][i];
        if (!mark[e.to]&&e.cap)
        {
            if (dis[x]+e.cost==dis[e.to])
            {
                int f=dfs(e.to,t,min(flow,e.cap));
                e.cap-=f; edge[e.to][e.rev].cap+=f;
                ret+=f; flow-=f;
                if (flow==0) break;
            }
        }
    }
    mark[x]=0;
    return ret;
}
pair<int,ll> mc(int s,int t,int n)
{
    int ret=0;
    ll ans=0;
    int flow = inf;
    while(flow)
    {
        spfa(s,t,n); if (dis[t]==inf) break;
        memset(cur,0,sizeof cur);
        int len=dis[t],f;
        while ((f=dfs(s,t,flow))>0)
            ret+=f,ans+=(ll)len*(ll)f,flow-=f;
    }
    return make_pair(ret,ans);//最大流，最小费用
}
```

```
88    void init(int n)
89    {
90        for(int i = 1; i <= n; i++) edge[i].clear();
91    }
92 }
```

4 数学

4.1 高斯消元

```
1  const int N = 307;
2  int x[N],a[N][N];// x[N]解集，a[N][N]系数
3  bool free_x[N];
4  int gcd(int a,int b){return b ? gcd(b,a % b) : a;}
5  int lcm(int a,int b){return a / gcd(b,a % b) * b;}
6  int Gauss(int equ,int var)//equ个方程，var个变元
7  {
8      int
          free_x_num,i,j,row,max_r,col;//row表示行,col表示列,max_r表示列最大的行,free_x_num变元数量
9      int free_index,LCM,ta,tb,temp;// free_index变元下标
10     for(i = 0;i <= var;++i){
11         x[i] = 0;
12         free_x[i] = true;//第i个元素是否是变元
13     }
14     for(row = 0,col = 0;row < equ && col < var;++row,++col){
15         max_r = row;
16         //找到col最大的行，进行交换（除法时减小误差）
17         for(i = row + 1;i < equ;++i) if(abs(a[i][col]) > abs(a[max_r][col])) max_r =
               i;
18         //与第row行交换
19         if(max_r != row) for(j = row;j < var + 1;++j) swap(a[row][j],a[max_r][j]);
20         if(a[row][col]==0){
21             //说明该col列第row行以下全是0了，则处理当前行的下一列.
22             row--;
23             continue;
24         }
```

```
25      for(i = row + 1;i < equ;++i)//枚举被删行
26          if(a[i][col]){
27              LCM = lcm(abs(a[i][col]),abs(a[row][col]));
28              ta = LCM / abs(a[i][col]);
29              tb = LCM / abs(a[row][col]);
30              if(a[i][col] * a[row][col] < 0)tb = -tb;//异号的情况是相加
31              for(j = col;j < var + 1;++j)
32                  a[i][j] = a[i][j] * ta - a[row][j] * tb;
33          }
34      /*求解小数解,防止溢出
35      for(int i = row + 1; i < equ; ++i)
36          if(fabs(a[i][col]) > eps){
37              double t1 = a[i][col]/a[row][col];
38              for(int j = col; j <= var;++j) a[i][j] -= a[row][j] * t1;
39          }*/
40      }
41  for (i = row;i < equ;++i) if(a[i][col]) return -1; // 无解
42  if (row < var){// 多解
43      for(i = row - 1;i >= 0;--i){
44          free_x_num = 0;
45          for (j = 0;j < var;++j)
46              if(a[i][j] && free_x[j]) free_x_num++,free_index = j;
47          if (free_x_num > 1) continue; // 无法求解出确定的变元.
48          temp = a[i][var];
49          for (j = 0;j < var;++j) if (a[i][j] && j != free_index) temp -= a[i][j]
                  * x[j];
50          x[free_index] = temp / a[i][free_index]; //求出该变元.
51          free_x[free_index] = 0; //该变元是确定的.
52      }
53      return var - row; //自由变元有 var - row 个.
54  }
55  for (i = var - 1; i >= 0;--i){// 唯一解
56      temp = a[i][var];
57      for (j = i + 1;j < var;++j)
58          if (a[i][j]) temp -= a[i][j] * x[j];
59      if (temp % a[i][i]) return -2; // 说明有浮点数解,但无整数解.
60      x[i] = temp / a[i][i];
```

```
61        }
62    return 0;
63 }
```

4.1.1 fft

```
1 namespace fft
2 {
3     struct num
4     {
5         double x,y;
6         num() {x=y=0;}
7         num(double x,double y):x(x),y(y){}
8     };
9     inline num operator+(num a,num b) {return num(a.x+b.x,a.y+b.y);}
10    inline num operator-(num a,num b) {return num(a.x-b.x,a.y-b.y);}
11    inline num operator*(num a,num b) {return num(a.x*b.x-a.y*b.y,a.x*b.y+a.y*b.x);}
12    inline num conj(num a) {return num(a.x,-a.y);}
13
14    int base=1;
15    vector<num> roots={{0,0},{1,0}};
16    vector<int> rev={0,1};
17    const double PI=acosl(-1.0);
18
19    void ensure_base(int nbase)
20    {
21        if(nbase<=base) return;
22        rev.resize(1<<nbase);
23        for(int i=0;i<(1<<nbase);i++)
24            rev[i]=(rev[i>>1]>>1)+((i&1)<<(nbase-1));
25        roots.resize(1<<nbase);
26        while(base<nbase)
27        {
28            double angle=2*PI/(1<<(base+1));
29            for(int i=1<<(base-1);i<(1<<base);i++)
30            {
31                roots[i<<1]=roots[i];
```

```
32              double angle_i=angle*(2*i+1-(1<<base));
33              roots[(i<<1)+1]=num(cos(angle_i),sin(angle_i));
34          }
35          base++;
36      }
37  }
38
39  void fft(vector<num> &a,int n=-1)
40  {
41      if(n==-1) n=a.size();
42      assert((n&(n-1))==0);
43      int zeros=__builtin_ctz(n);
44      ensure_base(zeros);
45      int shift=base-zeros;
46      for(int i=0;i<n;i++)
47          if(i<(rev[i]>>shift))
48              swap(a[i],a[rev[i]>>shift]);
49      for(int k=1;k<n;k<<=1)
50      {
51          for(int i=0;i<n;i+=2*k)
52          {
53              for(int j=0;j<k;j++)
54              {
55                  num z=a[i+j+k]*roots[j+k];
56                  a[i+j+k]=a[i+j]-z;
57                  a[i+j]=a[i+j]+z;
58              }
59          }
60      }
61  }
62
63  vector<num> fa,fb;
64
65  vector<int> multiply(vector<int> &a, vector<int> &b)
66  {
67      int need=a.size()+b.size()-1;
68      int nbase=0;
```

```
69        while((1<<nbase)<need) nbase++;
70        ensure_base(nbase);
71        int sz=1<<nbase;
72        if(sz>(int)fa.size()) fa.resize(sz);
73        for(int i=0;i<sz;i++)
74        {
75            int x=(i<(int)a.size()?a[i]:0);
76            int y=(i<(int)b.size()?b[i]:0);
77            fa[i]=num(x,y);
78        }
79        fft(fa,sz);
80        num r(0,-0.25/sz);
81        for(int i=0;i<=(sz>>1);i++)
82        {
83            int j=(sz-i)&(sz-1);
84            num z=(fa[j]*fa[j]-conj(fa[i]*fa[i]))*r;
85            if(i!=j) fa[j]=(fa[i]*fa[i]-conj(fa[j]*fa[j]))*r;
86            fa[i]=z;
87        }
88        fft(fa,sz);
89        vector<int> res(need);
90        for(int i=0;i<need;i++) res[i]=fa[i].x+0.5;
91        return res;
92    }
93
94    vector<int> multiply_mod(vector<int> &a,vector<int> &b,int m,int eq=0)
95    {
96        int need=a.size()+b.size()-1;
97        int nbase=0;
98        while((1<<nbase)<need) nbase++;
99        ensure_base(nbase);
100       int sz=1<<nbase;
101       if(sz>(int)fa.size()) fa.resize(sz);
102       for(int i=0;i<(int)a.size();i++)
103       {
104           int x=(a[i]%m+m)%m;
105           fa[i]=num(x&((1<<15)-1),x>>15);
```

```
106             }
107             fill(fa.begin()+a.size(),fa.begin()+sz,num{0,0});
108             fft(fa,sz);
109             if(sz>(int)fb.size()) fb.resize(sz);
110             if(eq) copy(fa.begin(),fa.begin()+sz,fb.begin());
111             else
112             {
113                 for(int i=0;i<(int)b.size();i++)
114                 {
115                     int x=(b[i]%m+m)%m;
116                     fb[i]=num(x&((1<<15)-1),x>>15);
117                 }
118                 fill(fb.begin()+b.size(),fb.begin()+sz,num{0,0});
119                 fft(fb,sz);
120             }
121             double ratio=0.25/sz;
122             num r2(0,-1),r3(ratio,0),r4(0,-ratio),r5(0,1);
123             for(int i=0;i<=(sz>>1);i++)
124             {
125                 int j=(sz-i)&(sz-1);
126                 num a1=(fa[i]+conj(fa[j]));
127                 num a2=(fa[i]-conj(fa[j]))*r2;
128                 num b1=(fb[i]+conj(fb[j]))*r3;
129                 num b2=(fb[i]-conj(fb[j]))*r4;
130                 if(i!=j)
131                 {
132                     num c1=(fa[j]+conj(fa[i]));
133                     num c2=(fa[j]-conj(fa[i]))*r2;
134                     num d1=(fb[j]+conj(fb[i]))*r3;
135                     num d2=(fb[j]-conj(fb[i]))*r4;
136                     fa[i]=c1*d1+c2*d2*r5;
137                     fb[i]=c1*d2+c2*d1;
138                 }
139                 fa[j]=a1*b1+a2*b2*r5;
140                 fb[j]=a1*b2+a2*b1;
141             }
142             fft(fa,sz);fft(fb,sz);
```

```
143        vector<int> res(need);
144        for(int i=0;i<need;i++)
145        {
146            ll aa=fa[i].x+0.5;
147            ll bb=fb[i].x+0.5;
148            ll cc=fa[i].y+0.5;
149            res[i]=(aa+((bb%m)<<15)+((cc%m)<<30))%m;
150        }
151        return res;
152    }
153    vector<int> square_mod(vector<int> &a,int m)
154    {
155        return multiply_mod(a,a,m,1);
156    }
157 };
```

4.2 线性基

HDU6579 [l,r] 最大异或和

```
1  struct LB
2  {
3      ll p[33];
4      int g[33];
5      void ins(ll x,int pos)
6      {
7          per(i,0,30)
8          {
9              if((x>>i) & 1)
10             {
11                 if(p[i])
12                 {
13                     if(g[i] <= pos)
14                     {
15                         x ^= p[i];
16                         p[i] ^= x;
17                         swap(g[i],pos);
```

```
18                    }
19                else
20                    x ^= p[i];
21            }
22            else
23            {
24                p[i] = x;
25                g[i] = pos;
26                break;
27            }
28        }
29      }
30    }
31    ll query(int l)
32    {
33        ll res = 0;
34        per(i,0,30)
35        {
36            if(g[i] >= l)
37            {
38                res = max(res,res^p[i]);
39            }
40        }
41        return res;
42    }
43 } base[maxn];
44
45 int n,m;
46
47 int gao(int x,int lastans)
48 {
49     return (x^lastans) % n + 1;
50 }
51
52 int T;
53 int x;
54
```

```
55  int main(int argc, char const *argv[])
56  {
57      // ios_base::sync_with_stdio(false), cin.tie(0), cout.tie(0);
58      scanf("%d",&T);
59      while(T--)
60      {
61          scanf("%d%d",&n,&m);
62          rep(i,1,n+1)
63          {
64              scanf("%d",&x);
65              base[i] = base[i-1];
66              base[i].ins(x,i);
67          }
68          ll ans = 0;
69          int l,r;
70          while(m--)
71          {
72              int op;
73              scanf("%d",&op);
74              if(!op)
75              {
76                  scanf("%d%d",&l,&r);
77                  l = gao(l,ans);r=gao(r,ans);
78                  if(l>r) swap(l,r);
79                  ans = base[r].query(l);
80                  printf("%lld\n",ans);
81              }
82              else
83              {
84                  n++;
85                  scanf("%d",&l);
86                  base[n] = base[n-1];
87                  base[n].ins(l^ans,n);
88              }
89          }
90      }
91      return 0;
```

```
92 }
```

5 计算几何

5.1 处理平面内所有直线围成的所有多边形

```cpp
const int MAXN=1e6+10;
const double eps=1e-8;
const double pi=acos(-1.0);
const ll INF=0x3f3f3f3f3f3f3f3f;

inline int dcmp(double x){
    if(fabs(x)<eps) return 0;
    return (x>0? 1: -1);
}

inline double sqr(double x){ return x*x; }

struct Point{
    double x,y;
    Point(){ x=0,y=0; }
    Point(double _x,double _y):x(_x),y(_y){}
    void input(){ scanf("%lf%lf",&x,&y); }
    void output(){ printf("%.2f %.2f\n",x,y); }
    friend istream &operator >>(istream &os,Point &b){
        os>>b.x>>b.y;
        return os;
    }
    friend ostream &operator <<(ostream &os,Point &b){
        os<<b.x<<' '<<b.y;
        return os;
    }
    bool operator ==(const Point &b)const{
        return (dcmp(x-b.x)==0&&dcmp(y-b.y)==0);
    }
    bool operator !=(const Point &b)const{
```

```cpp
        return !((dcmp(x-b.x)==0&&dcmp(y-b.y)==0));
    }
    bool operator <(const Point &b)const{
        return (dcmp(x-b.x)==0? dcmp(y-b.y)<0 : x<b.x);
    }
    double operator ^(const Point &b)const{ //叉积
        return x*b.y-y*b.x;
    }
    double operator *(const Point &b)const{ //点积
        return x*b.x+y*b.y;
    }
    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);
    }
    Point operator *(double a){
        return Point(x*a,y*a);
    }
    Point operator /(double a){
        return Point(x/a,y/a);
    }
    double len2(){ //长度平方
        return sqr(x)+sqr(y);
    }
    double len(){ //长度
        return sqrt(len2());
    }
    double polar(){ //向量的极角
        return atan2(y,x); //返回与x轴正向夹角(-pi~pi]
    }
    Point change_len(double r){ //转化为长度为r的向量
        double l=len();
        if(dcmp(l)==0) return *this; //零向量
        return Point(x*r/l,y*r/l);
    }
```

```
68      Point rotate_left(){ //逆时针旋转90度
69          return Point(-y,x);
70      }
71      Point rotate_right(){ //顺时针旋转90度
72          return Point(y,-x);
73      }
74      Point rotate(Point p,double ang){ //绕点p逆时针旋转ang度
75          Point v=(*this)-p;
76          double c=cos(ang),s=sin(ang);
77          return Point(p.x+v.x*c-v.y*s,p.y+v.x*s+v.y*c);
78      }
79      Point normal(){  //单位化，逆时针旋转90°
80          return Point(-y/len(),x/len());
81      }
82  };
83
84  inline double cross(Point a,Point b){ //叉积
85      return a.x*b.y-a.y*b.x;
86  }
87
88  inline double dot(Point a,Point b){ //点积
89      return a.x*b.x+a.y*b.y;
90  }
91
92
93  double rad(Point a,Point b){ //两个向量的夹角
94      return fabs(atan2(fabs(cross(a,b)),dot(a,b)));
95  }
96
97  bool is_parallel(Point a,Point b){ //判断向量是否平行
98      double p=rad(a,b);
99      return dcmp(p)==0||dcmp(p-pi)==0;
100 }
101
102 struct Line{
103     Point s,e;
104     Line(){}
```

```
105    Line(Point _s,Point _e):s(_s),e(_e){} //两点确定直线
106    Line(Point p,double ang){ //一个点和斜率(弧度制)确定直线
107        s=p;
108        if(dcmp(ang-pi/2)==0){
109            e=s+Point(0,1);
110        }
111        else{
112            e=s+Point(1,tan(ang));
113        }
114    }
115    Line(double a,double b,double c){ //ax+by+c=0
116        if(dcmp(a)==0){
117            s=Point(0,-c/b);
118            e=Point(1,-c/b);
119        }
120        else if(dcmp(b)==0){
121            s=Point(-c/a,0);
122            e=Point(-c/a,1);
123        }
124        else{
125            s=Point(0,-c/b);
126            e=Point(1,(-c-a)/b);
127        }
128    }
129    void input(){
130        s.input();
131        e.input();
132    }
133    void adjust(){
134        if(e<s) swap(e,s);
135    }
136    double polar(){ //极角
137        return atan2(e.y-s.y,e.x-s.x); //返回与x轴正向夹角(-pi~pi]
138    }
139    double angle(){  //倾斜角
140        double k=atan2(e.y-s.y,e.x-s.x);
141        if(dcmp(k)<0) k+=pi;
```

```
142            if(dcmp(k-pi)==0) k-=pi;
143            return k;
144        }
145        Point operator &(const Line &b)const{ //求两直线交点
146            Point res=s;
147            double t=((s-b.s)^(b.s-b.e))/((s-e)^(b.s-b.e));
148            res.x+=(e.x-s.x)*t;
149            res.y+=(e.y-s.y)*t;
150            return res;
151        }
152    };
153
154    double polygon_area(vector<Point> p){ //多边形的有向面积，加上绝对值就是面积
           正值表示输入点按照逆时针 否则为顺时针
155        int n=p.size(); double area=0;
156        for(int i=1;i<n-1;i++) area+=cross(p[i]-p[0],p[i+1]-p[0]);
157        return fabs(area/2);
158    }
159
160    struct PSLG{  //平面直线图 处理平面内所有直线围成的所有多边形 传入直线交点之间的每条线段
161        struct Edge{
162            int from,to;
163            double ang;
164            Edge(){ ang=from=to=0; }
165            Edge(int s,int t,double a){ from=s,to=t,ang=a; }
166        };
167        int n,m,face_cnt; //平面个数 包括外面最大的多边形
168        double area[MAXN]; //每个多边形面积
169        Point point[MAXN]; //平面内所有的点
170        vector<Edge>edge;
171        vector<int>G[MAXN];
172        vector<vector<Point> >face;
173        int vis[2*MAXN],left[2*MAXN],pre[2*MAXN]; //left表示这条边的左侧属于哪个面
174        void Init(){
175            face.clear();
176            edge.clear();
177            for(int i=0;i<n;i++) G[i].clear();
```

```
178          n=m=0;
179      }
180      PSLG(){ Init(); }
181      void AddEdge(int from, int to){        //需要建立反向边帮助寻找下一条边
182          edge.pb(Edge(from,to,(point[to]-point[from]).polar()));
183          edge.pb(Edge(to,from,(point[from]-point[to]).polar()));
184          m=edge.size();
185          G[from].pb(m-2);
186          G[to].pb(m-1);
187      }
188      void Build(){
189          for(int u=0;u<n;u++){
190              int d=G[u].size();
191              for(int i=0;i<d;i++)
192                  for(int j=i+1;j<d;j++)
193                      if(edge[G[u][i]].ang>edge[G[u][j]].ang)
194                          swap(G[u][i],G[u][j]);
195              for(int i=0;i<d;i++) pre[G[u][(i+1)%d]]=G[u][i];
                     //从u出发的i条边顺时针旋转的第一条边是pre[i]
196          }
197          face_cnt=0; memset(vis,0,sizeof(vis));
198          for(int u=0;u<n;u++){
199              for(int i=0;i<G[u].size();i++){
200                  int e=G[u][i];
201                  if(!vis[e]){
202                      face_cnt++;
203                      vector<Point> polygon;
204                      while(1){
205                          vis[e]=1;
206                          left[e]=face_cnt;
207                          int from=edge[e].from;
208                          polygon.pb(point[from]);
209                          e=pre[e^1];        //逆时针旋转最多的一条边即为顺时针转动的第一条边
210                          if(e==G[u][i]) break;
211                      }
212                      face.pb(polygon);
213                  }
```

```
214                 }
215             }
216         for(int i=0;i<face_cnt;i++) area[i]=polygon_area(face[i]);
217     }
218     vector<pair<double,int> >tmp[MAXN];
219     void Insert(Line *line,int m){
220         for(int i=0;i<m;i++){
221             for(int j=i+1;j<m;j++){
222                 if(!is_parallel(line[i].e-line[i].s,line[j].e-line[j].s)){
223                     Point inter=line[i]&line[j];
224                     point[n++]=inter;
225                     tmp[i].pb({dot(inter-line[i].s,line[i].e-line[i].s),n-1});
226                     tmp[j].pb({dot(inter-line[j].s,line[j].e-line[j].s),n-1});
227                 }
228             }
229             sort(tmp[i].begin(),tmp[i].end());
230             for(int j=1;j<tmp[i].size();j++) AddEdge(tmp[i][j-1].se,tmp[i][j].se);
231         }
232         Build();
233     }
234 }pslg;
235
236 Line line[MAXN];
237
238 int main(void){
239     int n; scanf("%d",&n);
240     for(int i=0;i<n;i++) line[i].input();
241     pslg.Insert(line,n);
242     sort(pslg.area,pslg.area+pslg.face_cnt);
243     printf("%d %.6f
244         %.6f\n",pslg.face_cnt-1,pslg.area[pslg.face_cnt-2],pslg.area[0]);
244     int q; scanf("%d",&q);
245     while(q--){
246         int p; scanf("%d",&p);
247         if(p>=pslg.face_cnt) puts("Invalid question");
248         else    printf("%.6f\n",pslg.area[pslg.face_cnt-p-1]);
249     }
```

```
250    return 0;
251 }
```

6　字符串

6.1　kmp

- board

```
1  void get_fail(int f[],char s[])
2  {
3      int j = f[0] = 0;
4      int n = strlen(s);
5      rep(i,1,n)
6      {
7          while(j && s[i] != s[j]) j = f[j-1];
8          f[i] = j += s[i] == s[j];
9      }
10 }
```

- kmp

```
1  void kmp(int f[],char p[],char s[])
2  {
3      int n = strlen(s);
4      int m = strlen(p);
5      int j = 0;
6      rep(i,0,n)
7      {
8          while(j && s[i] != p[j]) j = f[j-1];
9          if(s[i] == p[j]) j++;
10         if(j == m)
11         {
12             cout << i - j + 2 << endl;
13             j = f[j-1];
14         }
```

```
15     }
16 }
```

6.2 SA

```
1 const int N=4e5+100;
2 const int maxn = 2e5+100;
3 const int inf=1e9+9;
4
5 namespace SA {
6     char s[N];
7     int sa[N],x[N],y[N],hep[N],height[N],n,m;
8     void init()
9     {
10         n = 0;
11     }
12     void add(char c)
13     {
14         // c -= 'a';
15         n++;
16         s[n]=c;
17     }
18     void Sort() {
19         for(int i=0;i<=m;++i) hep[i]=0;
20         for(int i=1;i<=n;++i) ++hep[x[i]];
21         for(int i=1;i<=m;++i) hep[i]+=hep[i-1];
22         for(int i=n;i>=1;--i) sa[hep[x[y[i]]]--]=y[i];
23     }
24     void Pre_sa() {
25         for(int i=1;i<=n;++i) x[i]=s[i],y[i]=i;
26         m=223;Sort();
27         for(int w=1,p=0;m=p,p<n;w<<=1) {
28             p=0;
29             for(int i=1;i<=w;++i) y[++p]=n-w+i;
30             for(int i=1;i<=n;++i) if(sa[i]>w) y[++p]=sa[i]-w;
31             Sort(),swap(x,y),x[sa[1]]=p=1;
```

```
32          for(int i=2;i<=n;++i)
33              x[sa[i]]=(y[sa[i]]==y[sa[i-1]]&&y[sa[i]+w]==y[sa[i-1]+w])?p:++p;
34      }return;
35      }
36      ll Pre_height() {
37          for(int i=1;i<=n;++i) x[sa[i]]=i;
38          int k=0,res=0;
39          for(int i=1;i<=n;++i) {
40              k-=k>0;
41              int j=sa[x[i]-1];
42              while(i+k<=n&&j+k<=n&&s[i+k]==s[j+k]) ++k;
43              height[x[i]]=k,res+=k;
44          }return res;//直接返回height数组的和
45      }
46      ll solve()
47      {
48          /**
49          给你一个长为N的字符串，求不同的子串的个数?
50          对于一个后缀sa[i]，它产生了n-sa[i]个前缀，减去height[i]个相同的前缀(与前一个比较)，
51          则产生了n-sa[i]-height[i]个子串。累加后即结果。
52          */
53          ll ans = 0;
54          for (int i = 1; i <= n; i++)
55          {
56              ans += n + 1 - sa[i] - height[i];
57          }
58          return ans;
59      }
60      ll gao()
61      {
62          Pre_sa();
63          Pre_height();
64          return solve();
65      }
66  }
```

6.3 回文树 1

```cpp
struct Pal
{
    int ch[maxn][26],f[maxn],len[maxn],s[maxn];
    int cnt[maxn];
    int num[maxn];
    int last,sz,n;

    int newnode(int x)
    {
        memset(ch[sz],0,sizeof(ch[sz]));
        cnt[sz] = num[sz] = 0, len[sz] = x;
        return sz++;
    }
    void init()
    {
        sz = 0;
        newnode(0),newnode(-1);
        last = n = 0,s[0] = -1,f[0] = 1;
    }

    int get_fail(int u)
    {
        while(s[n - len[u] - 1] != s[n])
            u = f[u];
        return u;
    }

    void add(int c)
    {
        c -= 'a';
        s[++n] = c;
        int u = get_fail(last);
        if(!ch[u][c])
        {
            int np = newnode(len[u] + 2);
            f[np] = ch[get_fail(f[u])][c];
```

```
37             num[np] = num[f[np]] + 1;
38             ch[u][c] = np;
39         }
40         last = ch[u][c];
41         cnt[last]++;
42     }
43
44     void count()
45     {
46         for(int i = sz - 1;~i;i--)
47         cnt[f[i]] += cnt[i];
48     }
49 } pa;
```

6.4　回文树 2

```
1  struct Palindromic_Tree {
2      int son[N][26]; //转移边
3      int fail[N]; //fail 指针
4      int cnt[N]; //当前节点表示的回文串在原串中出现了多少次
5      int num[N]; //当前节点 fail 可以向前跳多少次
6      int len[N]; //当前节点表示的回文串的长度
7      int S[N]; //插入的字符串
8      int last; //最后一次访问到的节点，类似 SAM
9      int n; //插入的字符串长度
10     long long p; //自动机的总状态数
11
12     int newnode(int l) {
13         memset(son[p], 0, sizeof(son[p]));
14         cnt[p] = 0;
15         num[p] = 0;
16         len[p] = l;
17         return p++;
18     }
19
20     void init() {
```

```
21          p = 0;
22          newnode(0);
23          newnode(-1);
24          last = 0;
25          n = 0;
26          S[n] = -1;
27          fail[0] = 1;
28      }
29
30      int get_fail(int x) {
31          while (S[n - len[x] - 1] != S[n]) x = fail[x];
32          return x;
33      }
34
35      void add(int c) {
36          c -= 'a';
37          S[++n] = c;
38          int cur = get_fail(last); //通过上一次访问的位置去扩展
39          if (!son[cur][c]) { //如果没有对应的节点添加一个新节点
40              int now = newnode(len[cur] + 2);
41              fail[now] = son[get_fail(fail[cur])][c]; //通过当前节点的 fail
                    去扩展出新的 fail
42              son[cur][c] = now;
43              num[now] = num[fail[now]] + 1; //记录 fail 跳多少次
44          }
45          last = son[cur][c];
46          cnt[last]++; //表示当前节点访问了一次
47      }
48      void count() {
49          //如果某个节点出现一次，那么他的 fail 也一定会出现一次，并且在插入的时候没有计数
50          for (int i = p - 1; i >= 0; i--) cnt[fail[i]] += cnt[i];
51      }
52  } AUT;
```

7 杂项

7.1 退火

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

using namespace std;

const int maxn = 1e5 + 10;
const double eps = 1e-8;
const double delta = 0.98;
const double inf = 1e18;

struct Point { double x, y; } p[maxn];

double dis(Point A, Point B) { return sqrt((A.x - B.x) * (A.x - B.x) + (A.y - B.y) * (A.y - B.y)); };

double Simulate_Annea(int n)
{
    Point S;
    S.x = S.y = 0;
    double t = 1000;
    double res = inf;
    while(t > eps)
    {
        int k = 0;
        for(int i = 0; i < n; i ++) if(dis(S, p[i]) > dis(S, p[k])) k = i;
        double d = dis(S, p[k]);
        res = min(res, d);
        S.x += (p[k].x - S.x) / d * t;
        S.y += (p[k].y - S.y) / d * t;
        t *= delta;
    }
    return res;
}

```

```
33  int main()
34  {
35      int n;
36      scanf("%d", &n);
37      for(int i = 0; i < n; i ++) scanf("%lf%lf", &p[i].x, &p[i].y);
38      printf("%.3f\n", Simulate_Annea(n));
39      return 0;
40  }
```