NCTU_TaNoShiI

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1 String

1.1 AC

```
struct Node{
  Node *index[30];
  Node *fail;
  int word;
  int num;
  Node(){
    for(int i=0;i<30;i++)
    index[i]=NULL;
    fail=NULL;
    word=0;
    num=-1;
  }
}*root=new Node();
void add(char c[]){
  Node *n=root;
  for(int i=0;c[i]!=0;i++){

    if(!n->index[c[i]-'a'])
    n->index[c[i]-'a']=new Node();
    n=n->index[c[i]-'a'];
  }
  n->word=1;
  n->num=t++;
}
void ac(){
  queue<Node*> q;
  q.push(root);
  root->fail=NULL;
  while(!q.empty()){
    Node *n=q.front();
    q.pop();
    for(int i=0;i<30;i++){
      if(n->index[i]){
        q.push(n->index[i]);
        Node* p=n->fail;
        while(p!=NULL&&!p->index[i])
        p=p->fail;
        if(p)
        n->index[i]->fail=p->index[i];
        else
        n->index[i]->fail=root;
      }
    }
  }
}
void search(char c[]){
  Node *n=root;
  for(int i=0;c[i]!=0;i++){

    while(!n->index[c[i]-'a']&&n!=root){
      n=n->fail;
    }
    if(n->index[c[i]-'a'])
    n=n->index[c[i]-'a'];
    Node *p=n;
    while(p){
      if(p->num!=-1)
      {
        ans[p->num]++;
      }
      p=p->fail;
    }
  }
}
void del(Node *n=root){
  for(int i=0;i<30;i++)
  if(n->index[i])
  del(n->index[i]);
  free(n);
}
```

1.2 SuffixAutomata

```
// BZOJ 3998
const int MAX_N = 500000 + 10;
struct Node {
    static Node mem[MAX_N<<1] , *pmem;
    Node *ch[26] , *fail;
    int mx , val;
    ll dp;
    int tag , deg;
    Node():mx(0),fail(0),dp(0),val(0),tag(0),deg(0){
        MS(ch , 0);
    }
}
Node::mem[MAX_N<<1] , *Node::pmem = Node::mem , *root
, *last;
int T , N;
char s[MAX_N];
inline void init() {
    last = root = new (Node::pmem++)Node();
}
inline int idx(char c) {
    return c -'a';
}
inline void insert(char c) {
    c = idx(c);
    Node *p = last;
    Node *np = new (Node::pmem++)Node();
    np->mx = p->mx + 1;
    np->val = 1;
    while(p && !p->ch[c]) {
        p->ch[c] = np;
        np->deg++;
        p = p->fail;
    }
    if(!p) np->fail = root;
    else
    {
        Node *q = p->ch[c];
        if(q->mx == p->mx + 1) np->fail = q;
        else
        {
            Node *nq = new (Node::pmem++)Node();
            nq->mx = p->mx + 1;
            nq->val = 0;
            memcpy(nq->ch , q->ch , sizeof(q->ch));
            REP(i , 26) {
                if(nq->ch[i]) nq->ch[i]->deg++;
            }
            nq->fail = q->fail;
            q->fail = np->fail = nq;
            while(p && p->ch[c] == q) {
                p->ch[c] = nq;
                q->deg--;
                nq->deg++;
                p = p->fail;
            }
        }
    }
    last = np;
}
inline void bfs() {
    static Node* que[MAX_N<<1];
    int l = 0 , r = 0;
    que[r++] = root;
    root->tag = 2;
    vector<Node*> vec;
    while(l < r) {
        Node *u = que[l++];
        REP(i , 26) {
            if(u->ch[i]) {
                if(--u->ch[i]->deg == 0 && u->ch[i]->
                tag != 1) {
                    u->ch[i]->tag = 1;
                    que[r++] = u->ch[i];
                    vec.PB(u->ch[i]);
                }
            }
        }
    }
    for(int i = SZ(vec) - 1; i >= 0; i--) {
        Node *u = vec[i];
        if(T) {
            if(u->fail) u->fail->val += u->val;
        }
        else u->val = 1;
    }
    root->val = 0;
    for(int i = SZ(vec) - 1; i >= 0; i--) {
        Node *u = vec[i];
        u->dp = u->val;
        REP(j , 26) {
            if(u->ch[j]) u->dp += u->ch[j]->dp;
        }
    }
    REP(i , 26) {
        if(root->ch[i]) root->dp += root->ch[i]->dp;
    }
}
inline void solve(int k) {
    Node *p = root;
    if(k > p->dp || k <= 0) {
        puts("-1");
        return;
    }
    while(k > 0) {
        int flag = 0;
        REP(i , 26) {
            if(!p->ch[i]) continue;
            if(k <= p->ch[i]->dp) {
                putchar('a' + i);
                k -= p->ch[i]->val;
                p = p->ch[i];
                flag = 1;
                break
                ;
            }
            else k -= p->ch[i]->dp;
        }
        if(!flag) break;
    }
}
int main() {
    scanf("%s",s);
    int n = strlen(s);
    N = n;
    init();
    REP(i , n) insert(s[i]);
    int K;
    scanf("%d%d",&T,&K);
    bfs();
    solve(K);
    return 0;
}
```

1.3 MinLexicographicalRotate

```
string mcp(string s){
    int n = s.length();
    s += s;
    int i=0, j=1;
    while (i<n && j<n){
        int k = 0;
        while (k < n && s[i+k] == s[j+k]) k++;
        if (s[i+k] <= s[j+k]) j += k+1;
        else i += k+1;
        if (i == j) j++;
    }
    int ans = i < n ? i : j;
    return s.substr(ans, n);
}
```

1.4 ZvaluePalindromes

```
inline void manacher(char *s,int len,int *z){
  int l=0,r=0;
  for(int i=1;i<len;++i){
    z[i]=r>i?min(z[2*l-i],r-i):1;
    while(s[i+z[i]]==s[i-z[i]])++z[i];
    if(z[i]+i>r)r=z[i]+i,l=i;
  }
}
```

1.5 SuffixArray

```
int ss[N];
int heigh[N];
int sa[N];
int rank[N];
int length;
int val[30];
int c[N];   // counting sort array
int temp[2][N];
void suffix_array()
{
    int A = 250;
    int* rank = temp[0];
    int* new_rank = temp[1];
    for (int i=0; i<A; ++i) c[i] = 0;
    for (int i=0; i<length; ++i) c[rank[i] = ss[i]]++;
    for (int i=1; i<A; ++i) c[i] += c[i-1];
    for (int i=length-1; i>=0; --i) sa[--c[ss[i]]] = i;
    for (int n=1; n<length; n*=2)
    {
        for (int i=0; i<A; ++i) c[i] = 0;
        for (int i=0; i<length; ++i) c[rank[i]]++;
        for (int i=1; i<A; ++i) c[i] += c[i-1];
        int* sa2 = new_rank;
        int r = 0;
        for (int i=length-n; i<length; ++i)
            sa2[r++] = i;
        for (int i=0; i<length; ++i)
            if (sa[i] >= n)
                sa2[r++] = sa[i] - n;
        for (int i=length-1; i>=0; --i)
            sa[--c[rank[sa2[i]]]] = sa2[i];
        new_rank[sa[0]] = r = 0;
        for (int i=1; i<length; ++i)
        {
            if (!(rank[sa[i-1]] == rank[sa[i]] &&
                sa[i-1]+n < length &&    // stable sort trick
                rank[sa[i-1]+n] == rank[sa[i]+n]))
                r++;
            new_rank[sa[i]] = r;
        }
        swap(rank, new_rank);
        if (r == length-1) break;
        A = r + 1;
    }
}
void lcp_array()
{
    for (int i=0; i<length; ++i)
        rank[sa[i]] = i;

    for (int i=0, lcp=0,h=0; i<length; i++)
        if (rank[i] == 0)
            heigh[0] = 0;
        else
        {
            int j = sa[rank[i]-1];
            if (lcp > 0) lcp-=val[ss[i-1]-'a'],h--;
            while (ss[i+h] == ss[j+h]) lcp+=val[ss[i+h]-'a'],h++;
            heigh[rank[i]] = lcp;
        }
}
```

1.6 Zvalue

```
inline void z_alg1(char *s,int len,int *z){
  int l=0,r=0;
  z[0]=len;
  for(int i=1;i<len;++i){
    z[i]=r>i?min(r-i+1,z[z[l]-(r-i+1)]):0;
    while(i+z[i]<len&&s[z[i]]==s[i+z[i]])++z[i];
    if(i+z[i]-1>r)r=i+z[i]-1,l=i;
  }
}
```

2 Math

2.1 MillerRabin

```
// 4759123141 2, 7, 61
//2^64 2, 325, 9375, 28178, 450775, 9780504, 1795265022
bool Isprime(LL n)
{
    if (n == 2) return true;
    if (n < 2 || n % 2 == 0) return false;
    LL u = n - 1, t = 0;
    while (u % 2 == 0) {u >>= 1; t++;}
    LL sprp[7] = {2, 325, 9375, 28178, 450775, 9780504, 1795265022};
    for (int k=0; k<7; ++k)
    {
        LL a = sprp[k] % n;
        if (a == 0 || a == 1 || a == n-1) continue;
        long long x = f_pow(a, u, n);
        if (x == 1 || x == n-1) continue;
        for (int i = 0; i < t-1; i++)
        {
            x = f_pow(x, 2, n);
            if (x == 1) return false;
            if (x == n-1) break;
        }
        if (x == n-1) continue;
        return false;
    }
    return true;
}
```

2.2 FFT

```
#define N 524288
#define pi acos(-1)
typedef complex<double> C;
int n,m,i,t,g[N];
C a[N],b[N];
void FFTinit(){
  for (i=1;i<N;i++) g[i]=g[i>>1]>>1|((i&1)<<18);
}
void FFT(C *a,int f)
{
  int i,j,k,p;
  for (i=0;i<N;i++)
    if (g[i]>i) swap(a[i],a[g[i]]);
  for (i=1;i<N;i<<=1)
  {
    C e(cos(pi/i),f*sin(pi/i));
    for (j=0;j<N;j+=i<<1)
  {
   C w(1,0);for (k=0;k<i;k++,w*=e)
   {
    C x=a[j+k],y=w*a[j+k+i];
    a[j+k]=x+y;a[j+k+i]=x-y;
   }
  }
 }
}
int res[400005];
int main()
{
 FFTinit();
 FFT(a,1);
 FFT(b,1);
 for(i=0;i<N;i++) a[i]=a[i]*b[i];
 FFT(a,-1);
 for (i=0;i<n+m;i++)
 (int)a[i].real()/N+0.5)
}
```

2.3 Extgcd

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

2.4 Pollard'sRho

```
// does not work when n is prime
inline LL f(LL x , LL mod) {
return (x * x % mod + 1) % mod;
}
inline LL pollard_rho(LL n) {
 if(!(n&1)) return 2;
 while(true) {
  LL y = 2 , x = rand() % (n - 1) + 1 , res = 1;
  for(int sz = 2; res == 1; sz *= 2) {
   for(int i = 0; i < sz && res <= 1; i++) {
    x = f(x , n);
    res = __gcd(abs(x - y) , n);
   }
   y = x;
  }
  if (res != 0 && res != n) return res;
 }
}
```

3 Other

3.1 Annealing

```
double distForAllPoints(double x, double y,
      vector< pair<int, int> > &D) {
 double sum = 0;
 for(int i = D.size()-1; i >= 0; i--) {
  sum += hypot(D[i].first - x, D[i].second - y);
 }
 return sum;
}
double randDouble() {
 return (rand() % 32767) / 32767.0;
}
double annealing(vector< pair<int, int> > &D) {
#define S_MUL 0.6f
#define S_LEN 1000
#define T_CNT 10
#define E_CNT 10
 double step = S_LEN;
 double x[E_CNT], y[E_CNT], val[E_CNT];
 double Lx, Ly, Rx, Ry, tx, ty, tcost;
 Lx = Rx = D[0].first;
 Ly = Ry = D[0].second;
 for(int i = 0; i < D.size(); i++) {
  Lx = min(Lx, (double)D[i].first);
  Rx = max(Rx, (double)D[i].first);
  Ly = min(Ly, (double)D[i].second);
  Ry = max(Ry, (double)D[i].second);
 }
 for(int i = 0; i < E_CNT; i++) {
  x[i] = randDouble() * (Rx - Lx) + Lx;
  y[i] = randDouble() * (Ry - Ly) + Ly;
  val[i] = distForAllPoints(x[i], y[i], D);
 }
 while(step > 0.1) {
  for(int i = 0; i < E_CNT; i++) {
   for(int j = 0; j < T_CNT; j++) {
    tx = x[i] + randDouble() * 2 * step - step;
    ty = y[i] + randDouble() * 2 * step - step;
    tcost = distForAllPoints(tx, ty, D);
    if(tcost < val[i]) {
     val[i] = tcost, x[i] = tx, y[i] = ty;
    }
   }
  }
  step *= S_MUL;
 }
 double ret = val[0];
 for(int i = 0; i < E_CNT; i++) {
  ret = min(ret, val[i]);
 }
 printf("%.0lf\n", ret);
}
int main() {
 int testcase, N;
 scanf("%d", &testcase);
 while(testcase--) {
  scanf("%d", &N);
  vector< pair<int, int> > D;
  int x, y;
  for(int i = 0; i < N; i++) {
   scanf("%d %d", &x, &y);
   D.push_back(make_pair(x, y));
  }
  annealing(D);
  if(testcase)
   puts("");
 }
 return 0;
}
```

3.2 DLX

```
struct DLX{
  int n,m,len;
  int U[maxnode],D[maxnode],R[maxnode],L[maxnode],
  Row[maxnode],Col[maxnode];
  int H[maxn];
  int S[maxm];
  int ansd,ans[maxn];

  void init(int _n,int _m){
    n = _n;m = _m;
    for(int i = 0; i <= m; i++){
      S[i] = 0;
      U[i] = D[i] = i;
      L[i] = i-1;
      R[i] = i+1;
    }
    R[m] = 0,L[0] = m;
    len = m;
    for(int i = 1; i <= n; i++)
      H[i] = -1;
  }
```

```

    void link(int r,int c){
        ++S[Col[++len]=c];
        Row[len] = r;
        D[len] = D[c];
        U[D[c]] = len;
        U[len] = c;
        D[c] = len;
        if(H[r] < 0)
            H[r] = L[len] = R[len] = len;
        else{
            R[len] = R[H[r]];
            L[R[H[r]]] = len;
            L[len] = H[r];
            R[H[r]] = len;
        }
    }

    void del(int c){
        L[R[c]] = L[c];
        R[L[c]] = R[c];
        for(int i = D[c]; i != c; i = D[i]){
            for(int j = R[i]; j != i; j = R[j]){
                U[D[j]] = U[j];
                D[U[j]] = D[j];
                --S[Col[j]];
            }
        }
    }

    void resume(int c){
        for(int i = U[c]; i != c; i = U[i]){
            for(int j = L[i]; j != i; j = L[j]){
                ++S[Col[U[D[j]]=D[U[j]]=j]];
            }
        }
        L[R[c]] = R[L[c]] = c;
    }

    void dance(int d){
        //剪枝
        if(ansd != -1 && ansd <= d)
            return;
        if(R[0] == 0){
            if(ansd == -1)
                ansd = d;
            else if(d < ansd)
                ansd = d;
            return ;
        }
        int c = R[0];
        for(int i = R[0]; i != 0; i = R[i]){
            if(S[i] < S[c])
                c = i;
        }
        del(c);
        for(int i = D[c]; i != c; i = D[i]){
            ans[d] = Row[i];
            for(int j = R[i]; j != i; j = R[j])
                del(Col[j]);
            dance(d+1);
            for(int j = L[i]; j != i; j = L[j])
                resume(Col[j]);
        }
        resume(c);
    }
};
```

3.3 MahattanMST

```
#include<bits/stdc++.h>
#define REP(i,n) for(int i=0;i<n;i++)
using namespace std;
typedef long long LL;
const int N=200100;
int n,m;
struct PT {int x,y,z,w,id;}p[N];
inline int dis(const PT &a,const PT &b){return abs(a.xb.x)+abs(a.y-b.y);}
inline bool cpx(const PT &a,const PT &b){return a.x!=b.
x? a.x>b.x:a.y>b.y;}
inline bool cpz(const PT &a,const PT &b){return a.z<b.z
;}
struct E{int a,b,c;}e[8*N];
bool operator<(const E&a,const E&b){return a.c<b.c;}
struct Node{
    int L,R,key;
}node[4*N];
int s[N];
int F(int x){return s[x]==x?x:s[x]=F(s[x]);}
void U(int a,int b){s[F(b)]=F(a);}
void init(int id,int L,int R) {
    node[id]=(Node){L,R,-1};
    if(L==R)return
    ;
    init(id*2,L,(L+R)/2);
    init(id*2+1,(L+R)/2+1,R);
}
void ins(int id,int x) {
    if(node[id].key==-1 || p[node[id].key].w>p[x].w)node[
    id].key=x;
    if(node[id].L==node[id].R)return
    ;
    if(p[x].z<=(node[id].L+node[id].R)/2)ins(id*2,x);
    else ins(id*2+1,x);
}
int Q(int id,int L,int R){
    if(R<node[id].L || L>node[id].R)return -1;
    if(L<=node[id].L && node[id].R<=R)return node[id].key ;
    int a=Q(id*2,L,R),b=Q(id*2+1,L,R);
    if(b==-1 || (a!=-1 && p[a].w<p[b].w)) return a;
    else return b;
}
void calc() {
    REP(i,n) {
        p[i].z=p[i].y-p[i].x;
        p[i].w=p[i].x+p[i].y;
    }
    sort(p,p+n,cpz);
    int cnt=0,j,k;
    for
    (int i=0;i<n;i=j){
        for(j=i+1;p[j].z==p[i].z && j<n;j++);
        for(k=i,cnt++;k<j;k++)p[k].z=cnt;
    }
    init(1,1,cnt);
    sort(p,p+n,cpx);
    REP(i,n) {
        j=Q(1,p[i].z,cnt);
        if(j!=-1)e[m++]=(E){p[i].id,p[j].id,dis(p[i],p[j])
        };
        ins(1,i);
    }
}
LL MST() {
    LL r=0;
    sort(e,e+m);
    REP(i,m) {
        if(F(e[i].a)==F(e[i].b))continue;
        U(e[i].a,e[i].b);
        r+=e[i].c;
    }
    return r;
}
int main(){
    int ts;
    scanf("%d", &ts);
    while (ts--) {
        m = 0;
        scanf("%d",&n);
        REP(i,n) {scanf("%d%d",&p[i].x,&p[i].y);p[i].id=s[i]=i;}
        calc();
        REP(i,n)p[i].y= -p[i].y;
        calc();
        REP(i,n)swap(p[i].x,p[i].y);
        calc();
        REP(i,n)p[i].x=-p[i].x;
        calc();
        printf("%lld\n",MST()*2);
    }
    return 0;
}
```

3.4 MoOnTree

```
#include<bits/stdc++.h>
using namespace std;
#define IOS ios_base::sync_with_stdio(0); cin.tie(0);
#define SZ(x) ((int)((x).size()))
const int MX = 500005;
const int SQ = 1400;
const int LOG = 17;
struct BIT {
    int bit[MX];
    int lb(int x) { return x & -x; }
    void add(int p, int v) {
        p++;
        for (int i=p; i<MX; i+=lb(i)) bit[i] += v;
    }
    int qry() {
        int v = 0;
        for (int i=1<<LOG; i>0; i>>=1) {
            if ((v|i) < MX and bit[v|i]==i) v |= i;
        }
        return v;
    }
}bit;
struct Query {
    int l,r,qid;
}qry[MX];
struct Edge {
    int v,x;
};
int N,Q,timestamp[MX],ans[MX];
int in[MX],cnt[MX];
vector<Edge> E[MX];
vector<Edge> seq;
void DFS(int u, int f) {
    timestamp[u] = SZ(seq);
    for (auto it:E[u]) {
        if (it.v == f) continue;
        seq.push_back(it);
        DFS(it.v,u);
        seq.push_back(it);
    }
}
void poke(int id) {
    int v = seq[id].v;
    int x = seq[id].x;
    in[v] ^= 1;
    cnt[x] += in[v] ? 1 : -1;
    if (in[v] and cnt[x] == 1) bit.add(x, 1);
    if (!in[v] and cnt[x] == 0) bit.add(x, -1);
}
int main() {
    IOS;
    cin >> N >> Q;
    for (int i=0; i<N-1; i++) {
        int u,v,x;
        cin >> u >> v >> x;
        x = min(x,N);
        E[u].push_back({v,x});
        E[v].push_back({u,x});
    }
    DFS(1,1);
    for (int i=1; i<=Q; i++) {
        int u,v;
        cin >> u >> v;
        int l = timestamp[u], r = timestamp[v];
        if (l > r) swap(l,r);
        r--;
        qry[i] = {l,r,i};
    }
    sort(qry+1,qry+1+Q, [](Query a, Query b) {
        return make_pair(a.l/SQ,a.r) < make_pair(b.l/SQ,b.r);
    });
    int curL = 1, curR = 0;
    for (int i=1; i<=Q; i++) {
        int ql=qry[i].l,qr=qry[i].r;
        while (curL > ql) poke(--curL);
        while (curR < qr) poke(++curR);
        while (curL < ql) poke(curL++);
        while (curR > qr) poke(curR--);
        ans[qry[i].qid] = bit.qry();
    }
    for (int i=1; i<=Q; i++) cout << ans[i] << "\n";
    return 0;
}
```

3.5 Det

```
LL det(LL a[][20],int n)
{
    LL ret=1;
    for(int i=1;i<n;i++)
    {
        for(int j=i+1;j<n;j++)
            while(a[j][i])
            {
                LL t=a[i][i]/a[j][i];
                for(int k=i;k<n;k++)
                    a[i][k]=a[i][k]-a[j][k]*t;
                for(int k=i;k<n;k++)
                    swap(a[i][k],a[j][k]);
                ret=-ret;
            }
        if(a[i][i]==0)return 0;
        ret=ret*a[i][i];
    ret;
    }
    return ret;
}
```

4 DataStructure

4.1 PersistentTreap

```
const int MEM = 16000004;
struct Treap {
    static Treap nil, mem[MEM], *pmem;
    Treap *l, *r;
    char val;
    int size;
    Treap () : l(&nil), r(&nil), size(0) {}
    Treap (char _val) :
    l(&nil), r(&nil), val(_val), size(1) {}
} Treap::nil, Treap::mem[MEM], *Treap::pmem = Treap::mem;
int size(const Treap *t) { return t->size; }
void pull(Treap *t) {
    if (!size(t)) return;
    t->size = size(t->l) + size(t->r) + 1;
}
Treap* merge(Treap *a, Treap *b) {
    if (!size(a)) return b;
    if (!size(b)) return a;
    Treap *t;
    if (rand() % (size(a) + size(b)) < size(a)) {
        t = new (Treap::pmem++) Treap(*a);
        t->r = merge(a->r, b);
    } else {
        t = new (Treap::pmem++) Treap(*b);
        t->l = merge(a, b->l);
    }
    pull(t);
    return t;
}
void split(Treap *t, int k, Treap *&a, Treap *&b) {
    if (!size(t)) a = b = &Treap::nil;
    else if (size(t->l) + 1 <= k) {
        a = new (Treap::pmem++) Treap(*t);
        split(t->r, k - size(t->l) - 1, a->r, b);
        pull(a);
        } else {
        b = new (Treap::pmem++) Treap(*t);
        split(t->l, k, a, b->l);
        pull(b);
    }
}
int nv;
Treap *rt[50005];
void print(const Treap *t) {
    if (!size(t)) return;
    print(t->l);
    cout << t->val;
    print(t->r);
}
int main(int argc, char** argv) {
    IOS;
    rt[nv=0] = &Treap::nil;
    Treap::pmem = Treap::mem;
    int Q, cmd, p, c, v;
    string s;
    cin >> Q;
    while (Q--) {
        cin >> cmd;
        if (cmd == 1) {
            // insert string s after position p
            cin >> p >> s;
            Treap *tl, *tr;
            split(rt[nv], p, tl, tr);
            for (int i=0; i<s.size(); i++)
            tl = merge(tl, new (Treap::pmem++) Treap(s[i]))
            ;
            rt[++nv] = merge(tl, tr);
            } else if (cmd == 2) {
            // remove c characters starting at position
            Treap *tl, *tm, *tr;
            cin >> p >> c;
            split(rt[nv], p-1, tl, tm);
            split(tm, c, tm, tr);
            rt[++nv] = merge(tl, tr);
            } else if (cmd == 3) {
            // print c characters starting at position p, in version v
            Treap *tl, *tm, *tr;
            cin >> v >> p >> c;
            split(rt[v], p-1, tl, tm);
            split(tm, c, tm, tr);
            print(tm);
            cout << "n";
        }
    }
    return 0;
}
```

4.2 Pbds Kth

```
#include <bits/extc++.h>
using namespace __gnu_pbds;
typedef tree<int,null_type,less<int>,rb_tree_tag,
tree_order_statistics_node_update> set_t;
int main()
{
  // Insert some entries into s.
  set_t s;
  s.insert(12);s.insert(505);
  // The order of the keys should be: 12, 505.
  assert(*s.find_by_order(0) == 12);
  assert(*s.find_by_order(3) == 505);
  // The order of the keys should be: 12, 505.
  assert(s.order_of_key(12) == 0);
  assert(s.order_of_key(505) == 1);
  // Erase an entry.
  s.erase(12);
  // The order of the keys should be: 505.
  assert(*s.find_by_order(0) == 505);
  // The order of the keys should be: 505.
  assert(s.order_of_key(505) == 0);
}
```

4.3 PbdsHeap

```
#include <bits/extc++.h>
typedef __gnu_pbds::priority_queue<int> heap_t;
heap_t a,b;
int main() {
  a.clear();b.clear();
  a.push(1);a.push(3);
  b.push(2);b.push(4);
  assert(a.top() == 3);
  assert(b.top() == 4);
  // merge two heap
  a.join(b);
  assert(a.top() == 4);
  assert(b.empty());
  return 0;
}
```

4.4 Heavy-LightDecomposition

```
#define N
void init();//implement
int n,fa[N],belong[N],dep[N],sz[N],que[N];
int step,line[N],stPt[N],edPt[N];
vector<int> v[N], chain[N];
void DFS(int u){
    vector<int> &c = chain[belong[u]];
    for (int i=c.size()-1; i>=0; i--){
        int v = c[i];
        stPt[v] = step;
        line[step++] = v;
    }
    for (int i=0; i<(int)c.size(); i++){
        u = c[i];
        for (vector<int>::iterator it=v[u].begin(); it!=v[u].end();it++){
            if (fa[u] == *it || (i && *it == c[i-1])) continue;
            DFS(*it);
        }
        edPt[u] = step-1;
    }
}
void build_chain(int st){
    int fr,bk;
    fr=bk=0; que[bk++] = 1; fa[st]=st; dep[st]=0;
    while (fr < bk){
        int u=que[fr++];
        for (vector<int>::iterator it=v[u].begin(); it!=v[u].end();it++){
            if (*it == fa[u]) continue;
            que[bk++] = *it;
            dep[*it] = dep[u]+1;
            fa[*it] = u;
        }
    }
    for (int i=bk-1,u,pos; i>=0; i--){
        u = que[i]; sz[u] = 1; pos = -1;
        for (vector<int>::iterator it=v[u].begin(); it!=v[u].end();it++){
            if (*it == fa[u]) continue;
            sz[u] += sz[*it];
            if (pos==-1 || sz[*it]>sz[pos]) pos=*it;
        }
        if (pos == -1) belong[u] = u;
        else belong[u] = belong[pos];
        chain[belong[u]].pb(u);
    }
    step = 0;
    DFS(st);
}
int getLCA(int u, int v){
    while (belong[u] != belong[v]){
        int a = chain[belong[u]].back();
        int b = chain[belong[v]].back();
        if (dep[a] > dep[b]) u = fa[a];
        else v = fa[b];
    }
    return sz[u] >= sz[v] ? u : v;
}
vector<pii> getPathSeg(int u, int v){
    vector<pii> ret1,ret2;
    while (belong[u] != belong[v]){
        int a = chain[belong[u]].back();
        int b = chain[belong[v]].back();
        if (dep[a] > dep[b]){
            ret1.pb(mp(stPt[a],stPt[u]));
            u = fa[a];
            } else {
            ret2.pb(mp(stPt[b],stPt[v]));
            v = fa[b];
        }
    }
    if (dep[u] > dep[v]) swap(u,v);
    ret1.pb(mp(stPt[u],stPt[v]));
    reverse(ret2.begin(), ret2.end());
    ret1.insert(ret1.end(),ret2.begin(),ret2.end());
    return ret1;
}
// Usage
void build(){
    build_chain(1); //change root
    init();
}
int get_answer(int u, int v){
    int ret = -2147483647;
    vector<pii> vec = getPathSeg(u,v);
    for (vector<pii>::iterator it =vec.begin();it!=vec.end();it++);
     // check answer with segment [it.F, it.S]
    return ret;
}
```

4.5 KDtree

```
struct KDTree {
    struct Node {
        int x,y,x1,y1,x2,y2;
        int id,f;
        Node *L, *R;
    }tree[MXN];
    int n;
    Node *root;
    long long dis2(int x1, int y1, int x2, int y2) {
        long long dx = x1-x2;
        long long dy = y1-y2;
        return dx*dx+dy*dy;
    }
    static bool cmpx(Node& a, Node& b){ return a.x<b.x; }
    static bool cmpy(Node& a, Node& b){ return a.y<b.y; }
    void init(vector<pair<int,int>> ip) {
        n = ip.size();
        for (int i=0; i<n; i++) {
            tree[i].id = i;
            tree[i].x = ip[i].first;
            tree[i].y = ip[i].second;
        }
        root = build_tree(0, n-1, 0);
    }
    Node* build_tree(int L, int R, int dep) {
        if (L>R) return nullptr;
        int M = (L+R)/2;
        tree[M].f = dep%2;
        nth_element(tree+L, tree+M, tree+R+1, tree[M].f ?
        cmpy : cmpx);
        tree[M].x1 = tree[M].x2 = tree[M].x;
        tree[M].y1 = tree[M].y2 = tree[M].y;
        tree[M].L = build_tree(L, M-1, dep+1);
        if (tree[M].L) {
            tree[M].x1 = min(tree[M].x1, tree[M].L->x1);
            tree[M].x2 = max(tree[M].x2, tree[M].L->x2);
            tree[M].y1 = min(tree[M].y1, tree[M].L->y1);
            tree[M].y2 = max(tree[M].y2, tree[M].L->y2);
        }
        tree[M].R = build_tree(M+1, R, dep+1);
        if (tree[M].R) {
            tree[M].x1 = min(tree[M].x1, tree[M].R->x1);
            tree[M].x2 = max(tree[M].x2, tree[M].R->x2);
            tree[M].y1 = min(tree[M].y1, tree[M].R->y1);
            tree[M].y2 = max(tree[M].y2, tree[M].R->y2);
        }
        return tree+M;
    }
    int touch(Node* r, int x, int y, long long d2){
        long long dis = sqrt(d2)+1;
        if (x<r->x1-dis || x>r->x2+dis || y<r->y1-dis || y>
        r->y2+dis)
        return 0;
        return 1;
    }
    void nearest(Node* r, int x, int y, int &mID, long
    long &md2) {
        if (!r || !touch(r, x, y, md2)) return;
        long long d2 = dis2(r->x, r->y, x, y);
        if (d2 < md2 || (d2 == md2 && mID < r->id)) {
            mID = r->id;
            md2 = d2;
        }
        // search order depends on split dim
        if ((r->f == 0 && x < r->x) ||
        (r->f == 1 && y < r->y)) {
            nearest(r->L, x, y, mID, md2);
            nearest(r->R, x, y, mID, md2);
            } else {
            nearest(r->R, x, y, mID, md2);
            nearest(r->L, x, y, mID, md2);
        }
    }
    int query(int x, int y) {
        int id = 1029384756;
        long long d2 = 102938475612345678LL;
        nearest(root, x, y, id, d2);
        return id;
    }
}tree;
```

5 Default

5.1 Default

```
#include<bits/stdc++.h>
#define mp(a,b) make_pair((a),(b))
#define pii pair<int,int>
#define pdd pair<double,double>
#define pll pair<LL,LL>
#define pb(x) push_back(x)
#define x first
```

```
#define y second
#define sqr(x) ((x)*(x))
#define EPS 1e-6
#define mii map<int,int>
#define MEM(x) memset(x,0,sizeof(x))
#define MEMS(x) memset(x,-1,sizeof(x))
#define pi 3.14159265359
//#define INF 0x7fffffff
#define IOS ios_base::sync_with_stdio(0); cin.tie(0)
#define N 300005
using namespace std;
typedef long long LL;
```

6 Flow

6.1 Minimunwieghtmatchclique

```
struct Graph {
    // Minimum General Weighted Matching (Perfect Match) clique
    static const int MXN = 105;
    int n, edge[MXN][MXN];
    int match[MXN],dis[MXN],onstk[MXN];
    vector<int> stk;
    void init(int _n) {
        n = _n;
        MEM(edge);
    }
    void add_edge(int u, int v, int w) {
        edge[u][v] = edge[v][u] = w;
    }
    bool SPFA(int u){
        if (onstk[u]) return true;
        stk.pb(u);
        onstk[u] = 1;
        for (int v=0; v<n; v++){
            if (u != v && match[u] != v && !onstk[v]){
                int m = match[v];
                if (dis[m] > dis[u] - edge[v][m] + edge[u][v]){
                    dis[m] = dis[u] - edge[v][m] + edge[u][v];
                    onstk[v] = 1;
                    stk.pb(v);
                    if (SPFA(m)) return true;
                    stk.pop_back();
                    onstk[v] = 0;
                }
            }
        }
        onstk[u] = 0;
        stk.pop_back();
        return false;
    }
    int solve() {
        // find a match
        for (int i=0; i<n; i+=2){
            match[i] = i+1;
            match[i+1] = i;
        }
        while (true){
            int found = 0;
            MEM(dis); MEM(onstk);
            for (int i=0; i<n; i++){
                stk.clear();
                if (!onstk[i] && SPFA(i)){
                    found = 1;
                    while (stk.size()>=2){
                        int u = stk.back(); stk.pop_back();
                        int v = stk.back(); stk.pop_back();
                        match[u] = v;
                        match[v] = u;
                    }
                }
            }
            if (!found) break;
        }
        int ret = 0;
        for (int i=0; i<n; i++)
        ret += edge[i][match[i]];
        ret /= 2;
        return ret;
    }
}graph;
```

6.2 CostFlow

```
struct CostFlow {
    static const int MXN = 205;
    static const long long INF = 102938475610293847LL;
    struct Edge {
        int v, r;
        long long f, c;
        Edge(int a,int b,int _c,int d):v(a),r(b),f(_c),c(d){
    }
    };
    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(Edge(v, E[v].size() , f, c));
        E[v].pb(Edge(u, E[u].size()-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<E[u].size(); 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;
```

6.3 MincutTree

```
set<int> temp;
int Vis[3005];
int cvis[3005];
void dfs(int n){
  Vis[n]=1;
  for(auto it=v[n].begin();it!=v[n].end();it++){
    if(val[n][*it]>flow[n][*it]&&!Vis[*it]){
      dfs(*it);
      if(cvis[*it])
      temp.insert(*it);
    }
  }
}
int n;
int dc(set<int> s,int flag){
  if(s.size()==1)
  return *s.begin();
  for(int i=0;i<n;i++)
    for(auto it=v[i].begin();it!=v[i].end();it++)
    flow[i][*it]=0;
  for(auto it=s.begin();it!=s.end();it++){
    cvis[*it]=1;
  }
  int res=Flow(*s.begin(),*s.rbegin());
  MEM(Vis);
  dfs(*s.begin());
  temp.insert(*s.begin());
  for(auto it=s.begin();it!=s.end();it++){
    cvis[*it]=0;
  }
  set<int> s1,s2;
  swap(s1,temp);
  temp.clear();
  for(auto it=s1.begin();it!=s1.end();it++)
  s.erase(*it);
  swap(s2,s);
  int x=dc(s1,0);
  int y=dc(s2,1);
  vt[x].pb(mp(y,res));
  vt[y].pb(mp(x,res));
  if(flag==0)
  return x;
  else
  return y;
}
```

6.4 Dinic

```
struct Dinic{
    static const int MXN = 10000;
    struct Edge{ int v,f,re; Edge(int a,int b,int c):v(a),f(b),re(c){}};
    int n,s,t,level[MXN];
    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();
    }
    void add_edge(int u, int v, int f){
        E[u].pb(Edge(v,f,E[v].size()));
        E[v].pb(Edge(u,0,E[u].size()-1));//direct
    }
    bool BFS(){
        MEMS(level);
        queue<int> que;
        que.push(s);
        level[s] = 0;
        while (!que.empty()){
            int u = que.front(); que.pop();
            for (auto it : E[u]){
                if (it.f > 0 && level[it.v] == -1){
                    level[it.v] = level[u]+1;
                    que.push(it.v);
                }
            }
        }
        return level[t] != -1;
    }
    int DFS(int u, int nf){
        if (u == t) return nf;
        int res = 0;
        for (auto &it : E[u]){
            if (it.f > 0 && level[it.v] == level[u]+1){
                int tf = DFS(it.v, min(nf,it.f));
                res += tf; nf -= tf; it.f -= tf;
                E[it.v][it.re].f += tf;
                if (nf == 0) return res;
            }
        }
        if (!res) level[u] = -1;
        return res;
    }
    int flow(int res=0){
        while ( BFS() )
        res += DFS(s,2147483647);
        return res;
    }
}flow;
```

6.5 GeneralGraphmatch

```
struct GenMatch { // 1-base
    static const int MAXN = 505;
    int V;
    bool el[MAXN][MAXN];
    int pr[MAXN];
    bool inq[MAXN],inp[MAXN],inb[MAXN];
    queue<int> qe;
    int st,ed;
    int nb;
    int bk[MAXN],djs[MAXN];
    int ans;
    void init(int _V) {
        V = _V;
        MEM(el); MEM(pr);
        MEM(inq); MEM(inp); MEM(inb);
        MEM(bk); MEM(djs);
        ans = 0;
    }
    void add_edge(int u, int v) {
        el[u][v] = el[v][u] = 1;
    }
    int lca(int u,int v) {
        memset(inp,0,sizeof(inp));
        while(1) {
            u = djs[u];
            inp[u] = true;
            if(u == st) break;
            u = bk[pr[u]];
        }
        while(1) {
            v = djs[v];
            if(inp[v]) return v;
            v = bk[pr[v]];
        }
        return v;
    }
    void upd(int u) {
        int v;
        while(djs[u] != nb) {
            v = pr[u];
            inb[djs[u]] = inb[djs[v]] = true;
            u = bk[v];
            if(djs[u] != nb) bk[u] = v;
        }
    }
    void blo(int u,int v) {
        nb = lca(u,v);
        memset(inb,0,sizeof(inb));
        upd(u); upd(v);
        if(djs[u] != nb) bk[u] = v;
        if(djs[v] != nb) bk[v] = u;
        for(int tu = 1; tu <= V; tu++)
        if(inb[djs[tu]]) {
            djs[tu] = nb;
            if(!inq[tu]){
                qe.push(tu);
                inq[tu] = 1;
            }
        }
    }
    void flow() {
        memset(inq,false,sizeof(inq));
        memset(bk,0,sizeof(bk));
        for(int i = 1; i <= V;i++)
        djs[i] = i;
        while(qe.size()) qe.pop();
        qe.push(st);
        inq[st] = 1;
        ed = 0;
        while(qe.size()) {
            int u = qe.front(); qe.pop();
            for(int v = 1; v <= V; v++)
            if(el[u][v] && (djs[u] != djs[v]) && (pr[u] !=
            v)) {
                if((v == st) || ((pr[v] > 0) && bk[pr[v]] >
                0))
                blo(u,v);
                else if(bk[v] == 0) {
                    bk[v] = u;
                    if(pr[v] > 0) {
                        if(!inq[pr[v]]) qe.push(pr[v]);
                        } else {
                        ed = v;
                        return;
                    }
                }
            }
        }
    }
    void aug() {
        int u,v,w;
        u = ed;
        while(u > 0) {
            v = bk[u];
            w = pr[v];
            pr[v] = u;
            pr[u] = v;
            u = w;
        }
    }
    int solve() {
        memset(pr,0,sizeof(pr));
        for(int u = 1; u <= V; u++)
        if(pr[u] == 0) {
            st = u;
            flow();
            if(ed > 0) {
                aug();
                ans ++;
            }
        }
        return ans;
    }
}gp;
```

6.6 KM

```
typedef pair<long long, long long> pll;
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;
```

6.7 SWmincut

```
struct SW{ // O(V^3)
    static const int MXN = 514;
    int n,vst[MXN],del[MXN];
    int edge[MXN][MXN],wei[MXN];
    void init(int _n){
        n = _n;
        MEM(edge);
        MEM(del);
    }
    void add_edge(int u, int v, int w){
        edge[u][v] += w;
        edge[v][u] += w;
    }
    void search(int &s, int &t){
        MEM(vst); MEM(wei);
        s = t = -1;
        while (true){
```

```cpp
            int mx=-1, cur=0;
            for (int i=0; i<n; i++)
            if (!del[i] && !vst[i] && mx<wei[i])
            cur = i, mx = wei[i];
            if (mx == -1) break;
            vst[cur] = 1;
            s = t;
            t = cur;
            for (int i=0; i<n; i++)
            if (!vst[i] && !del[i]) wei[i] += edge[cur][i];
        }
    }
    int solve(){
        int res = 2147483647;
        for (int i=0,x,y; i<n-1; i++){
            search(x,y);
            res = min(res,wei[y]);
            del[y] = 1;
            for (int j=0; j<n; j++)
            edge[x][j] = (edge[j][x] += edge[y][j]);
        }
        return res;
    }
}graph;
```

7 Geometry

7.1 Circleintersection

```cpp
using ld = double;
vector<pdd> interCircle(pdd o1, double r1, pdd o2,
double r2) {
    ld d2 = (o1 - o2) * (o1 - o2);
    ld d = sqrt(d2);
    if (d > r1+r2) return {};
    pdd u = 0.5*(o1+o2) + ((r2*r2-r1*r1)/(2*d2))*(o1-o2);
    double A = sqrt((r1+r2+d) * (r1-r2+d) * (r1+r2-d) *
    (-r1+r2+d));
    pdd v = A / (2*d2) * pdd(o1.S-o2.S, -o1.F+o2.F);
    return {u+v, u-v};
}
```

7.2 Fermat's Point

```cpp
#define F(n) Fi(i,n)
#define Fi(i,n) Fl(i,0,n)
#define Fl(i,l,n) for(int i=(l);i<(int)(n);++i)
#include <bits/stdc++.h>
// #include <ext/pb_ds/assoc_container.hpp>
// #include <ext/pb_ds/priority_queue.hpp>
using namespace std;
// using namespace __gnu_pbds;
const double pi = acos(-1), eps = 1e-9;
const double st = sin(pi/3), ct = cos(pi/3);
struct point {
  point(double x_ = 0, double y_ = 0): x(x_), y(y_) {}
  double x, y;
  inline friend istream& operator>>(istream &is, point &p) {
    is >> p.x >> p.y;
    return is;
  }
  inline friend ostream& operator<<(ostream &os, const point &p) {
    os << p.x << ' ' << p.y;
    return os;
  }
};
struct line {
  line(double a_ = 0, double b_ = 0, double c_ = 0): a(a_), b(b_), c(c_) {}
  double a, b, c;
  inline double calc(point p) {
    return a*p.x+b*p.y;
  }
};
inline double calc(double a, double b, point p) {
  return a*p.x+b*p.y;
}
inline double dist2(point a, point b) {
  return (a.x-b.x)*(a.x-b.x)+(a.y-b.y)*(a.y-b.y);
}
inline point rot(point O, point p) {
  p.x -= O.x, p.y -= O.y;
  return point(O.x+p.x*ct-p.y*st, O.y+p.x*st+p.y*ct);
}
inline line cln(point a, point b) {
  return line(a.y-b.y, b.x-a.x, calc(a.y-b.y, b.x-a.x, a));
}
inline point ntse(line f, line g) {
  double det = f.a*g.b-g.a*f.b, dx = f.c*g.b-g.c*f.b, dy = f.a*g.c-g.a*f.c;
  return point(dx/det, dy/det);
}
inline point fema(point a, point b, point c) {
  double la = dist2(b, c), lb = dist2(a, c), lc = dist2(a, b);
  double sa = sqrt(la), sb = sqrt(lb), sc = sqrt(lc);
  if ((lb+lc-la)/(2.0*sb*sc) < -0.5 + eps)
    return a;
  if ((la+lc-lb)/(2.0*sa*sc) < -0.5 + eps)
    return b;
  if ((la+lb-lc)/(2.0*sa*sb) < -0.5 + eps)
    return c;
  point t1 = rot(a, b), t2 = rot(b, a);
  if (dist2(c, t1) < dist2(c, t2)) swap(t1, t2);
  point s1 = rot(b, c), s2 = rot(c, b);
  if (dist2(a, s1) < dist2(a, s2)) swap(s1, s2);
  return ntse(cln(c, t1), cln(a, s1));
}
int main() {
  ios_base::sync_with_stdio(false);
  cin.tie(NULL);
  point a, b, c;
  cin >> a >> b >> c;
  cout << setprecision(10) << fixed << fema(a, b, c) << '\n';
}
```

7.3 Pointoperators

```cpp
#define x first
#define y second
#define cpdd const pdd
struct pdd : pair<double, double> {
    using pair<double, double>::pair;
    pdd operator + (cpdd &p) const {
        return {x+p.x, y+p.y};
    }
    pdd operator - () const {
        return {-x, -y};
    }
    pdd operator - (cpdd &p) const {
        return (*this) + (-p);
    }
    pdd operator * (double f) const {
        return {f*x, f*y};
    }
    double operator * (cpdd &p) const {
        return x*p.x + y*p.y;
    }
};
double abs(cpdd &p) { return hypot(p.x, p.y); }
double arg(cpdd &p) { return atan2(p.y, p.x); }
double cross(cpdd &p, cpdd &q) { return p.x*q.y - p.y*q
.x; }
double cross(cpdd &p, cpdd &q, cpdd &o) { return cross(
p-o, q-o); }
pdd operator * (double f, cpdd &p) { return p*f; } //!! Not f*p !!
```

7.4 3DConvexHull

```
int flag[MXN][MXN];
struct Point{
    ld x,y,z;
    Point operator - (const Point &b) const {
        return (Point){x-b.x,y-b.y,z-b.z};
    }
    Point operator * (const ld &b) const {
        return (Point){x*b,y*b,z*b};
    }
    ld len() const { return sqrtl(x*x+y*y+z*z); }
    ld dot(const Point &a) const {
        return x*a.x+y*a.y+z*a.z;
    }
    Point operator * (const Point &b) const {
        return (Point){y*b.z-b.y*z,z*b.x-b.z*x,x*b.y-b.x*y
        };
    }
};
Point ver(Point a, Point b, Point c) {
    return (b - a) * (c - a);
}
vector<Face> convex_hull_3D(const vector<Point> pt) {
    int n = SZ(pt);
    REP(i,n) REP(j,n)
    flag[i][j] = 0;
    vector<Face> now;
    now.push_back((Face){0,1,2});
    now.push_back((Face){2,1,0});
    int ftop = 0;
    for (int i=3; i<n; i++){
        ftop++;
        vector<Face> next;
        REP(j, SZ(now)) {
            Face& f=now[j];
            ld d=(pt[i]-pt[f.a]).dot(ver(pt[f.a], pt[f.b], pt
            [f.c]));
            if (d <= 0) next.push_back(f);
            int ff = 0;
            if (d > 0) ff=ftop;
            else if (d < 0) ff=-ftop;
            flag[f.a][f.b] = flag[f.b][f.c] = flag[f.c][f.a]
            = ff;
        }
        REP(j, SZ(now)) {
            Face& f=now[j];
            if (flag[f.a][f.b] > 0 and flag[f.a][f.b] != flag
            [f.b][f.a])
            next.push_back((Face){f.a,f.b,i});
            if (flag[f.b][f.c] > 0 and flag[f.b][f.c] != flag
            [f.c][f.b])
            next.push_back((Face){f.b,f.c,i});
            if (flag[f.c][f.a] > 0 and flag[f.c][f.a] != flag
            [f.a][f.c])
            next.push_back((Face){f.c,f.a,i});
        }
        now=next;
    }
    return now;
}
```

7.5 Halfplaneintersection

```
typedef pdd Point;
typedef vector<Point> Polygon;
typedef pair<Point,Point> Line;
#define N 10
#define p1 first
#define p2 second
pdd operator-(const pdd &a,const pdd &b){
  return mp(a.x-b.x,a.y-b.y);
}
pdd operator+(const pdd &a,const pdd &b){
  return mp(a.x+b.x,a.y+b.y);
}
pdd operator*(const pdd &a,const double &b){
  return mp(b*a.x,b*a.y);
}
double cross(Point a, Point b){
  return a.x * b.y - a.y * b.x;
}
double cross(Point o, Point a, Point b){
  return cross(a-o,b-o);
}
double cross(Line l, Point p){
    return cross(l.p1, l.p2, p);
}
double arg(const pdd &a){
  return atan2(a.y,a.x);
}
bool parallel(Line l1, Line l2){
    return cross(l1.p2 - l1.p1, l2.p2 - l2.p1) < 1e-8&&cross(l1.p2 - l1.p1, l2.p2 - l2.p1) > -1e-8;
}
Point intersection(Line l1, Line l2){
    Point& a1 = l1.p1, &a2 = l1.p2;
    Point& b1 = l2.p1, &b2 = l2.p2;
    Point a = a2 - a1, b = b2 - b1, s = b1 - a1;
    return a1 + a * (cross(b, s) / cross(b, a));
}
bool cmp(Line l1, Line l2){
    return arg(l1.p2 - l1.p1) < arg(l2.p2 - l2.p1);
}
Polygon halfplane_intersection(vector<Line> hp){
    sort(hp.begin(), hp.end(), cmp);
    int L = 0, R = 0;
    vector<Line> l(N);
  vector<Point> p(N);
    l[R] = hp[0];
    for (int i=1; i<hp.size(); i++)
    {
        while (L < R && cross(hp[i], p[R-1]) < 0) R--;
        while (L < R && cross(hp[i], p[L])   < 0) L++;
        l[++R] = hp[i];
        if (parallel(l[R-1], hp[i]) &&
            cross(l[--R], hp[i].p1) > 0) l[R] = hp[i];
        if (L < R) p[R-1] = intersection(l[R], l[R-1]);
    }
    while (L < R && cross(l[L], p[R-1]) < 0) R--;
    if (R-L <= 1) return Polygon();//printf("?");
    if (L < R) p[R] = intersection(l[L], l[R]);
    Polygon ch;
    for (int i=L; i<=R; i++) ch.push_back(p[i]);
    ch.resize(unique(ch.begin(), ch.end()) - ch.begin());
    if (ch.size() > 1 && ch.front() == ch.back())
        ch.pop_back();
    return ch;
}
double cal(Polygon p){
  if(p.empty())
  return 0;
  p.pb(*p.begin());
  double ans=0;
  for(int i=0;i<p.size()-1;i++){
    ans+=p[i].x*p[i+1].y;
    ans-=p[i].y*p[i+1].x;
  }
  ans/=2;
  ans=abs(ans);
  return ans;
}
```

7.6 ConvexHull

```
sort(p,p+n);
pii ans[N];
ans[0]=p[0];
int k=0;
int now=0;
for(int yy=0;yy<2;yy++){
  for(int i=1;i<n;i++){
    while(now!=k&&(p[i].y-ans[now-1].y)*(ans[now].x-
    ans[now-1].x)<=(p[i].x-ans[now-1].x)*(ans[now].
    y-ans[now-1].y)){
      now--;
    }
    ans[++now]=p[i];
  }
  k=now;
  reverse(p,p+n);
}
```

7.7 Triangulation

```
bool inCircle(pdd a, pdd b, pdd c, pdd d) {
    b = b - a;
    c = c - a;
    d = d - a;
    if (cross(b, c) < 0) swap(b, c);
    double m[3][3] = {
        {b.x, b.y, b*b},
        {c.x, c.y, c*c},
        {d.x, d.y, d*d}
    };
    double det = m[0][0] * (m[1][1]*m[2][2] - m
    [1][2]*m
    [2][1])
    + m[0][1] * (m[1][2]*m[2][0] - m[1][0]*m
    [2][2])
    + m[0][2] * (m[1][0]*m[2][1] - m[1][1]*m
    [2][0]);
    return det < 0;
}
bool intersect(pdd a, pdd b, pdd c, pdd d) {
    return cross(b, c, a) * cross(b, d, a) < 0 and
    cross(d, a, c) * cross(d, b, c) < 0;
}
const double EPS = 1e-12;
struct Triangulation {
    static const int MXN = 1e5+5;
    int N;
    vector<int> ord;
    vector<pdd> pts;
    set<int> E[MXN];
    vector<vector<int>> solve(vector<pdd> p) {
        N = SZ(p);
        ord.resize(N);
        for (int i=0; i<N; i++) {
            E[i].clear();
            ord[i] = i;
        }
        sort(ALL(ord), [&p](int i, int j) {
            return p[i] < p[j];
        });
        pts.resize(N);
        for (int i=0; i<N; i++) pts[i] = p[ord[i]];
        go(0, N);
        vector<vector<int>> res(N);
        for (int i=0; i<N; i++) {
            int o = ord[i];
            for (auto x: E[i]) {
                res[o].PB(ord[x]);
            }
        }
        return res;
    }
    void add_edge(int u, int v) {
        E[u].insert(v);
        E[v].insert(u);
    }
    void remove_edge(int u, int v) {
        E[u].erase(v);
        E[v].erase(u);
    }
    void go(int l, int r) {
        int n = r - l;
        if (n <= 3) {
            for (int i=l; i<r; i++)
            for (int j=i+1; j<r; j++) add_edge(i, j
            );
            return;
        }
        int md = (l+r)/2;
        go(l, md);
        go(md, r);
        int il = l, ir = r-1;
        while (1) {
            int nx = -1;
            for (auto i: E[il]) {
                double cs = cross(pts[il], pts[i],
    pts[
                ir]);
                if (cs > EPS ||
                (abs(cs) < EPS and abs(pts[i]-pts[
                ir]) < abs(pts[il]-pts[ir]))) {
                    nx = i;
                    break;
                }
            }
            if (nx != -1) {
                il = nx;
                continue;
            }
            for (auto i: E[ir]) {
                double cs = cross(pts[ir], pts[i],
    pts[
                il]);
                if (cs < -EPS ||
                (abs(cs) < EPS and abs(pts[i]-pts[
                il]) < abs(pts[ir]-pts[il]))) {
                    nx = i;
                    break;
                }
            }
            if (nx != -1) {
                ir = nx;
            } else break;
        }
        add_edge(il, ir);
        while (1) {
            int nx = -1;
            bool is2 = false;
            National Taiwan University
    AcThPaUNpPuAmCmBkCfEsFmMdNoLr 19
            for (int i: E[il]) {
                if (cross(pts[il], pts[i], pts[ir])
    < -
                EPS and
                (nx == -1 or inCircle(pts[il], pts[
                ir], pts[nx], pts[i]))) nx = i;
            }
            for (int i: E[ir]) {
                if (cross(pts[ir], pts[i], pts[il])
    >
                EPS and
                (nx == -1 or inCircle(pts[il], pts[
                ir], pts[nx], pts[i]))) nx = i,
                is2 = 1;
            }
            if (nx == -1) break;
            int a = il, b = ir;
            if (is2) swap(a, b);
            for (auto i: E[a]) {
                if (intersect(pts[a], pts[i], pts[b
    ],
        pts[nx])) {
          remove_edge(a, i);
        }
      }
      if (is2) {
        add_edge(il, nx);
        ir = nx;
        } else {
        add_edge(ir, nx);
        il = nx;
      }
    }
  }
} tri;
```

7.8 K-closet Pair

```
#define F(n) Fi(i,n)
#define Fi(i,n) Fl(i,0,n)
#define Fl(i,l,n) for(int i=(l);i<(int)(n);++i)
#include <bits/stdc++.h>
// #include <ext/pb_ds/assoc_container.hpp>
// #include <ext/pb_ds/priority_queue.hpp>
using namespace std;
// using namespace __gnu_pbds;
typedef long long ll;
struct point {
  point(ll x_ = 0, ll y_ = 0): x(x_), y(y_) {}  ll x, y;
  inline bool operator<(const point &e_) const {
    return (x != e_.x ? x < e_.x : y < e_.y);
  }
  inline friend istream& operator>>(istream &is_, point& e_) {
    is_ >> e_.x >> e_.y;
    return is_;
  }
};
int k;
priority_queue<ll> PQ;
inline ll dist2(const point &e1, const point &e2) {
  ll res = (e1.x-e2.x)*(e1.x-e2.x)+(e1.y-e2.y)*(e1.y-e2.y);
  PQ.push(res);
  if (PQ.size() > k) {
    PQ.pop();
  }
  return res;
}
#define N 500005
point p[N];
queue<point> Q;
ll closet_point(int l, int m, int r, ll delta2) {
  ll xmid = p[m-1].x;
  while (!Q.empty()) {
    Q.pop();
  }
  for (int i = l, j = m ; i < m ; ++i) {
    if ((p[i].x-xmid)*(p[i].x-xmid) >= delta2) {
      continue;
    }
    while (j < r && p[j].y < p[i].y && (p[j].y-p[i].y)*(p[j].y-p[i].y) < delta2) {
      if ((p[j].x-xmid)*(p[j].x-xmid) < delta2) {
        Q.push(p[j]);
      }
      ++j;
    }
    while (!Q.empty() && Q.front().y < p[i].y && (Q.front().y-p[i].y)*(Q.front().y-p[i].y) > delta2) {
      Q.pop();
    }
    while (!Q.empty()) {
      delta2 = min(delta2, dist2(p[i], Q.front()));
      Q.pop();
    }
  }
  return delta2;
}
ll find_distance(int l, int r) {
  if (r - l <= 3000) {
    ll ans = 0x3f3f3f3f3f3f3f3f;
    for (int i = l ; i < r ; ++i)
      for (int j = i+1 ; j < r ; ++j)
        ans = min(ans, dist2(p[i], p[j]));
    return ans;
  }
  int m = (l+r)/2;
  ll delta2 = min(find_distance(l, m), find_distance(m, r));
  return min(delta2, closet_point(l, m, r, delta2));
}
int main() {
  ios_base::sync_with_stdio(false);
  cin.tie(NULL);
  int n;
  cin >> n >> k;
  F(n) cin >> p[i];
  sort(p, p+n);
  find_distance(0, n);
  cout << PQ.top() << '\n';
}
```

7.9 MCC

```
struct Mcc{
    // return pair of center and r^2
    static const int MAXN = 1000100;
    int n;
    pdd p[MAXN],cen;
    double r2;
    void init(int _n, pdd _p[]){
        n = _n;
        memcpy(p,_p,sizeof(pdd)*n);
    }
    double sqr(double a){ return a*a; }
    double abs2(pdd a){ return a*a; }
    pdd center(pdd p0, pdd p1, pdd p2) {
        pdd a = p1-p0;
        pdd b = p2-p0;
        double c1=abs2(a)*0.5;
        double c2=abs2(b)*0.5;
        double d = a.x*b.y-b.x*a.y;
        double x = p0.x + (c1 * b.y - c2 * a.y) / d;
        double y = p0.y + (a.x * c2 - b.x * c1) / d;
        return pdd(x,y);
    }
    pair<pdd,double> solve(){
        random_shuffle(p,p+n);
        r2=0;
        for (int i=0; i<n; i++){
            if (abs2(cen-p[i]) <= r2) continue;
            cen = p[i];
            r2 = 0;
            for (int j=0; j<i; j++){
                if (abs2(cen-p[j]) <= r2) continue;
                cen = 0.5 * (p[i]+p[j]);
                r2 = abs2(cen-p[j]);
                for (int k=0; k<j; k++){
                    if (abs2(cen-p[k]) <= r2) continue;
                    cen = center(p[i],p[j],p[k]);
                    r2 = abs2(cen-p[k]);
                }
            }
        }
        return {cen,r2};
    }
}mcc;
```

7.10 LineIntersection

```
pdd interPnt(pdd p1, pdd p2, pdd q1, pdd q2, bool & res)
{
    double f1 = cross(p2, q1, p1);
    double f2 = -cross(p2, q2, p1);
    double f = (f1 + f2);
    if(fabs(f) < EPS) {
        res = false;
        return {};
    }
    res = true;
    return (f2 / f) * q1 + (f1 / f) * q2;
}
```

7.11 PointToLine

```
double cal(const pii &a,const pii &b,const pii &c){
  int hi=dot(mp(a.x-b.x,a.y-b.y),mp(c.x-b.x,c.y-b.y));
  if(hi<=0){
    return dis(a,b);
  }
  hi=dot(mp(a.x-c.x,a.y-c.y),mp(b.x-c.x,b.y-c.y));
  if(hi<=0){
    return dis(c,a);
  }
  if(b.x==c.x)
  return abs(a.x-b.x);
  if(b.y==c.y)
  return abs(a.y-b.y);
  double B=(double)(b.x-c.x)/(b.y-c.y);
  double C=(double)(b.y*c.x-b.x*c.y)/(b.y-c.y);
  return abs(-a.x+B*a.y+C)/sqrt(1+sqr(B));
}
```

8 JAVA

8.1 Big Integer

```
import java.math.*;
import java.io.*;
import java.util.*;
public class Main{
    public static void main(String []argv){
        c[0][0]=BigInteger.ONE;
        for(int i=1;i<3001;i++){
            c[i][0]=BigInteger.ONE;
            c[i][i]=BigInteger.ONE;
            for(int j=1;j<i;j++)c[i][j]=c[i-1][j].add(c[i-1][j-1]);
        }
        Scanner scanner = new Scanner(System.in);
        int T = scanner.nextInt();
        BigInteger x;
        BigInteger ans;
        while(T-- > 0){
            ans = BigInteger.ZERO;
            int n = scanner.nextInt();
            for(int i=0;i<n;i++){
                x = new BigInteger(scanner.next());
                if(i%2 == 1)ans=ans.subtract(c[n-1][i].multiply(x));
                else ans=ans.add(c[n-1][i].multiply(x));
            }
            if(n%2 == 0)ans=BigInteger.ZERO.subtract(ans);
            System.out.println(ans);
        }
    }
}
```

8.2 Prime

```
import java.math.*;
import java.io.*;
import java.util.*;
public class Main{
    public static void main(String []argv){
        Scanner scanner = new Scanner(System.in);
        int T = scanner.nextInt();
        for (int cs = 0 ; cs < T ; cs++){
            if (cs != 0) { System.out.println(""); }
            int a = scanner.nextInt();
            int b = scanner.nextInt();
            for (int i = a ; i <= b ; i++) {
                BigInteger x = BigInteger.valueOf(i);
                if (x.isProbablePrime(5) == true) {
                    System.out.println(x);
                }
            }
        }
    }
}
```

9 Graph

9.1 MMC

```
/* minimum mean cycle 最小平均值環*/
const int MXN = 16004;
const int MAXE = 1805;
const int MAXN = 35;
const double inf = 1029384756;
const double eps = 1e-6;
struct Edge {
    int v,u;
    double c;
};
int n,m,prv[MAXN][MAXN], prve[MAXN][MAXN], vst[MAXN];
Edge e[MAXE];
vector<int> edgeID, cycle, rho;
double d[MAXN][MAXN];
inline void bellman_ford() {
    for(int i=0; i<n; i++) d[0][i]=0;
    for(int i=0; i<n; i++) {
        fill(d[i+1], d[i+1]+n, inf);
        for(int j=0; j<m; j++) {
            int v = e[j].v, u = e[j].u;
            if(d[i][v]<inf && d[i+1][u]>d[i][v]+e[j].c) {
                d[i+1][u] = d[i][v]+e[j].c;
                prv[i+1][u] = v;
                prve[i+1][u] = j;
            }
        }
    }
}
double karp_mmc() {
    // returns inf if no cycle, mmc otherwise
    double mmc=inf;
    int st = -1;
    bellman_ford();
    for(int i=0; i<n; i++) {
        double avg=-inf;
        for(int k=0; k<n; k++) {
            if(d[n][i]<inf-eps) avg=max(avg,(d[n][i]-d[k][i])
            /(n-k));
            else avg=max(avg,inf);
        }
        if (avg < mmc) tie(mmc, st) = tie(avg, i);
    }
    MEM(vst); edgeID.clear(); cycle.clear(); rho.clear();
    for (int i=n; !vst[st]; st=prv[i--][st]) {
        vst[st]++;
        edgeID.pb(prve[i][st]);
        rho.pb(st);
    }
    while (vst[st] != 2) {
        int v = rho.back(); rho.pop_back();
        cycle.pb(v);
        vst[v]++;
    }
    reverse(edgeID.begin(),edgeID.end());
    edgeID.resize(cycle.size());
    return mmc;
}
```

9.2 DMST

```
struct zhu_liu{
  static const int MAXN=1100,MAXM=1005005;
  struct node{
    int u,v;
    LL w,tag;
    node *l,*r;
    node(int u=0,int v=0,LL w=0):u(u),v(v),w(w),tag(0),l(0),r(0){}
    void down(){
      w+=tag;
      if(l)l->tag+=tag;
      if(r)r->tag+=tag;
      tag=0;
    }
  }mem[MAXM];
  node *pq[MAXN*2],*E[MAXN*2];
  int st[MAXN*2],id[MAXN*2],m,from[MAXN*2];
  void init(int n){
    for(int i=1;i<=n;++i){
      pq[i]=E[i]=0;
      st[i]=id[i]=i;
      from[i]=0;
    }m=0;
  }
  node *merge(node *a,node *b){//skew heap
    if(!a||!b)return a?a:b;
    a->down(),b->down();
    if(b->w<a->w)return merge(b,a);
    if(b->w==a->w&&b->v<a->v)return merge(b,a);//
    swap(a->l,a->r);
    a->l=merge(b,a->l);
    return a;
  }
  void add_edge(int u,int v,LL w){
    if(u!=v)pq[v]=merge(pq[v],&(mem[m++]=node(u,v,w)));
  }
  int find(int x,int *st){
    return st[x]==x?x:st[x]=find(st[x],st);
  }
  LL build(int root,int n){
    LL ans=0;int N=n,all=n;
    for(int i=1;i<=N;++i){
      if(i==root||!pq[i])continue;
      while(pq[i]){
        pq[i]->down(),E[i]=pq[i];
        pq[i]=merge(pq[i]->l,pq[i]->r);
        if(find(E[i]->u,id)!=find(i,id))break;
      }
      if(find(E[i]->u,id)==find(i,id))continue;
      from[E[i]->v]=E[i]->u;
      ans+=E[i]->w;
      if(find(E[i]->u,st)==find(i,st)){
        if(pq[i])pq[i]->tag-=E[i]->w;
        pq[++N]=pq[i],id[N]=N;
        for(int u=find(E[i]->u,id);u!=i;u=find(E[u]->u,id)){
          if(pq[u])pq[u]->tag-=E[u]->w;
          id[find(u,id)]=N;
          pq[N]=merge(pq[N],pq[u]);
        }
        st[N]=find(i,st);
        id[find(i,id)]=N;
      }else st[find(i,st)]=find(E[i]->u,st),--all;
    }
    return all==1?ans:-1;//圖不連通就無解
  }
}MST;
```

9.3 SCC

```
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();
        MEM(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++;
            }
        }
    }
};
```

9.4 GeneralGraphMaximunValueMatch

```
#include<bits/stdc++.h>
using namespace std;
//from vfleaking
//自己進行一些進行一些小修改
#define INF INT_MAX
#define MAXN 400
struct edge{
  int u,v,w;
  edge(){}
  edge(int u,int v,int w):u(u),v(v),w(w){}
};
int n,n_x;
edge g[MAXN*2+1][MAXN*2+1];
int lab[MAXN*2+1];
int match[MAXN*2+1],slack[MAXN*2+1],st[MAXN*2+1],pa[MAXN*2+1];
int flower_from[MAXN*2+1][MAXN+1],S[MAXN*2+1],vis[MAXN*2+1];
vector<int> flower[MAXN*2+1];
queue<int> q;
inline int e_delta(const edge &e){ // does not work inside blossoms
  return lab[e.u]+lab[e.v]-g[e.u][e.v].w*2;
}
```

```
inline void update_slack(int u,int x){
  if(!slack[x]||e_delta(g[u][x])<e_delta(g[slack[x]][x]))slack[x]=u;
}
inline void set_slack(int x){
  slack[x]=0;
  for(int u=1;u<=n;++u)
    if(g[u][x].w>0&&st[u]!=x&&S[st[u]]==0)update_slack(u,x);
}
void q_push(int x){
  if(x<=n)q.push(x);
  else for(size_t i=0;i<flower[x].size();i++)q_push(flower[x][i]);
}
inline void set_st(int x,int b){
  st[x]=b;
  if(x>n)for(size_t i=0;i<flower[x].size();++i)
      set_st(flower[x][i],b);
}
inline int get_pr(int b,int xr){
  int pr=find(flower[b].begin(),flower[b].end(),xr)-flower[b].begin();
  if(pr%2==1){//檢查他在前一層圖是奇點還是偶點
    reverse(flower[b].begin()+1,flower[b].end());
    return (int)flower[b].size()-pr;
  }else return pr;
}
inline void set_match(int u,int v){
  match[u]=g[u][v].v;
  if(u>n){
    edge e=g[u][v];
    int xr=flower_from[u][e.u],pr=get_pr(u,xr);
    for(int i=0;i<pr;++i)set_match(flower[u][i],flower[u][i^1]);
    set_match(xr,v);
    rotate(flower[u].begin(),flower[u].begin()+pr,flower[u].end());
  }
}
inline void augment(int u,int v){
  for(;;){
    int xnv=st[match[u]];
    set_match(u,v);
    if(!xnv)return;
    set_match(xnv,st[pa[xnv]]);
    u=st[pa[xnv]],v=xnv;
  }
}
inline int get_lca(int u,int v){
  static int t=0;
  for(++t;u||v;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v陣列
    u=st[match[u]];
    if(u)u=st[pa[u]];
  }
  return 0;
}
inline void add_blossom(int u,int lca,int v){
  int b=n+1;
  while(b<=n_x&&st[b])++b;
  if(b>n_x)++n_x;
  lab[b]=0,S[b]=0;
  match[b]=match[lca];
  flower[b].clear();
  flower[b].push_back(lca);
  for(int x=u,y;x!=lca;x=st[pa[y]])
    flower[b].push_back(x),flower[b].push_back(y=st[match[x]]),q_push(y);
  reverse(flower[b].begin()+1,flower[b].end());
  for(int x=v,y;x!=lca;x=st[pa[y]])
    flower[b].push_back(x),flower[b].push_back(y=st[match[x]]),q_push(y);
  set_st(b,b);
  for(int x=1;x<=n_x;++x)g[b][x].w=g[x][b].w=0;
  for(int x=1;x<=n;++x)flower_from[b][x]=0;
  for(size_t i=0;i<flower[b].size();++i){
    int xs=flower[b][i];
    for(int x=1;x<=n_x;++x)
      if(g[b][x].w==0||e_delta(g[xs][x])<e_delta(g[b][x]))
        g[b][x]=g[xs][x],g[x][b]=g[x][xs];
    for(int x=1;x<=n;++x)
      if(flower_from[xs][x])flower_from[b][x]=xs;
  }
  set_slack(b);
}
inline void expand_blossom(int b){ // S[b] == 1
  for(size_t i=0;i<flower[b].size();++i)
    set_st(flower[b][i],flower[b][i]);
  int xr=flower_from[b][g[b][pa[b]].u],pr=get_pr(b,xr);
  for(int i=0;i<pr;i+=2){
    int xs=flower[b][i],xns=flower[b][i+1];
    pa[xs]=g[xns][xs].u;
    S[xs]=1,S[xns]=0;
    slack[xs]=0,set_slack(xns);
    q_push(xns);
  }
  S[xr]=1,pa[xr]=pa[b];
  for(size_t i=pr+1;i<flower[b].size();++i){
    int xs=flower[b][i];
    S[xs]=-1,set_slack(xs);
  }
  st[b]=0;
}
inline bool on_found_edge(const edge &e){
  int u=st[e.u],v=st[e.v];
  if(S[v]==-1){
    pa[v]=e.u,S[v]=1;
    int nu=st[match[v]];
    slack[v]=slack[nu]=0;
    S[nu]=0,q_push(nu);
  }else if(S[v]==0){
    int lca=get_lca(u,v);
    if(!lca)return augment(u,v),augment(v,u),true;
    else add_blossom(u,lca,v);
  }
  return false;
}
inline bool matching(){
  memset(S+1,-1,sizeof(int)*n_x);
  memset(slack+1,0,sizeof(int)*n_x);
  q=queue<int>();
  for(int x=1;x<=n_x;++x)
    if(st[x]==x&&!match[x])pa[x]=0,S[x]=0,q_push(x);
  if(q.empty())return false;
  for(;;){
    while(q.size()){
      int u=q.front();q.pop();
      if(S[st[u]]==1)continue;
      for(int v=1;v<=n;++v)
        if(g[u][v].w>0&&st[u]!=st[v]){
          if(e_delta(g[u][v])==0){
            if(on_found_edge(g[u][v]))return true;
          }else update_slack(u,st[v]);
        }
    }
    int d=INF;
    for(int b=n+1;b<=n_x;++b)
      if(st[b]==b&&S[b]==1)d=min(d,lab[b]/2);
    for(int x=1;x<=n_x;++x)
      if(st[x]==x&&slack[x]){
        if(S[x]==-1)d=min(d,e_delta(g[slack[x]][x]));
        else if(S[x]==0)d=min(d,e_delta(g[slack[x]][x])/2);
      }
    for(int u=1;u<=n;++u){
      if(S[st[u]]==0){
        if(lab[u]<=d)return 0;
        lab[u]-=d;
      }else if(S[st[u]]==1)lab[u]+=d;
    }
    for(int b=n+1;b<=n_x;++b)
      if(st[b]==b){
        if(S[st[b]]==0)lab[b]+=d*2;
        else if(S[st[b]]==1)lab[b]-=d*2;
      }
    q=queue<int>();
    for(int x=1;x<=n_x;++x)
      if(st[x]==x&&slack[x]&&st[slack[x]]!=x&&
e_delta(g[slack[x]][x])==0)
        if(on_found_edge(g[slack[x]][x]))return true;
    for(int b=n+1;b<=n_x;++b)
      if(st[b]==b&&S[b]==1&&lab[b]==0)expand_blossom(b);
  }
  return false;
}
inline pair<long long,int> weight_blossom(){
  memset(match+1,0,sizeof(int)*n);
  n_x=n;
  int n_matches=0;
  long long tot_weight=0;
  for(int u=0;u<=n;++u)st[u]=u,flower[u].clear();
  int w_max=0;
  for(int u=1;u<=n;++u)
    for(int v=1;v<=n;++v){
      flower_from[u][v]=(u==v?u:0);
      w_max=max(w_max,g[u][v].w);
    }
  for(int u=1;u<=n;++u)lab[u]=w_max;
  while(matching())++n_matches;
  for(int u=1;u<=n;++u)
    if(match[u]&&match[u]<u)
      tot_weight+=g[u][match[u]].w;
  return make_pair(tot_weight,n_matches);
}
inline void init_weight_graph(){
  for(int u=1;u<=n;++u)
    for(int v=1;v<=n;++v)
      g[u][v]=edge(u,v,0);
}
int main(){
  int m;
  scanf("%d%d",&n,&m);
  init_weight_graph();
  for(int i=0;i<m;++i){
    int u,v,w;
    scanf("%d%d%d",&u,&v,&w);
    g[u][v].w=g[v][u].w=w;
  }
  printf("%lld\n",weight_blossom().first);
  for(int u=1;u<=n;++u)printf("%d ",match[u]);puts("");
  return 0;
}
```

9.5 Stable Marriage

```
#define F(n) Fi(i, n)
#define Fi(i, n) Fl(i, 0, n)
#define Fl(i, l, n) for(int i = l ; i < n ; ++i)
#include <bits/stdc++.h>
using namespace std;
int D, quota[205], weight[205][5];
int S, scoretodep[12005][205], score[5];
int P, prefer[12005][85], iter[12005];
int ans[12005];
typedef pair<int, int> PII;
map<int, int> samescore[205];
typedef priority_queue<PII, vector<PII>, greater<PII>> QQQ;
QQQ pri[205];
void check(int d) {
  PII t = pri[d].top();
  int v;
  if (pri[d].size() - samescore[d][t.first] + 1 <= quota[d]) return;
  while (pri[d].top().first == t.first) {
    v = pri[d].top().second;
    ans[v] = -1;
    --samescore[d][t.first];
    pri[d].pop();
  }
}
void push(int s, int d) {
  if (pri[d].size() < quota[d]) {
    pri[d].push(PII(scoretodep[s][d], s));
    ans[s] = d;
    ++samescore[s][scoretodep[s][d]];
  } else if (scoretodep[s][d] >= pri[d].top().first) {
    pri[d].push(PII(scoretodep[s][d], s));
    ans[s] = d;
    ++samescore[s][scoretodep[s][d]];
    check(d);
  }
}
void f() {
  int over;
  while (true) {
    over = 1;
    Fi (q, S) {
      if (ans[q] != -1 || iter[q] >= P) continue;
      push(q, prefer[q][iter[q]++]);
      over = 0;
    }
    if (over) break;
  }
}
main() {
  ios::sync_with_stdio(false);
  cin.tie(NULL);
  int sadmit, stof, dexceed, dfew;
  while (cin >> D, D) { // Beware of the input format or judge may troll us.
    sadmit = stof = dexceed = dfew = 0;
    memset(iter, 0, sizeof(iter));
    memset(ans, 0, sizeof(ans));
    Fi (q, 205) {
      pri[q] = QQQ();
      samescore[q].clear();
    }
    cin >> S >> P;
    Fi (q, D) {
      cin >> quota[q];
      Fi (w, 5) cin >> weight[q][w];
    }
    Fi (q, S) {
      Fi (w, 5) cin >> score[w];
      Fi (w, D) {
        scoretodep[q][w] = 0;
        F (5) scoretodep[q][w] += weight[w][i] * score[i];
      }
    }
    Fi (q, S) Fi (w, P) {
      cin >> prefer[q][w];
      --prefer[q][w];
    }
    f();
    Fi (q, D) sadmit += pri[q].size();
    Fi (q, S) if (ans[q] == prefer[q][0]) ++stof;
    Fi (q, D) if (pri[q].size() > quota[q]) ++dexceed;
    Fi (q, D) if (pri[q].size() < quota[q]) ++dfew;
    cout << sadmit << ' ' << stof << ' ' << dexceed << ' ' << dfew << '\n';
  }
}
```

9.6 BCCvertex

```
const int MXN = 16004;
struct BccVertex {
    int n,nScc,step,dfn[MXN],low[MXN];
    vector<int> E[MXN],sccv[MXN];
    int top,stk[MXN];
    void init(int _n) {
        n = _n;
        nScc = step = 0;
        for (int i=0; i<n; i++) E[i].clear();
    }
    void add_edge(int u, int v) {
        E[u].pb(v);
        E[v].pb(u);
    }
    void DFS(int u, int f) {
        dfn[u] = low[u] = step++;
        stk[top++] = u;
        for (auto v:E[u]) {
            if (v == f) continue;
            if (dfn[v] == -1) {
                DFS(v,u);
                low[u] = min(low[u], low[v]);
                if (low[v] >= dfn[u]) {
                    int z;
                    sccv[nScc].clear();
                    do {
                        z = stk[--top];
                        sccv[nScc].pb(z);
                    } while (z != v);
                    sccv[nScc].pb(u);
                    nScc++;
                }
                } else {
                low[u] = min(low[u],dfn[v]);
            }
        }
    }
    vector<vector<int>> solve() {
        vector<vector<int>> res;
        for (int i=0; i<n; i++) {
            dfn[i] = low[i] = -1;
        }
        for (int i=0; i<n; i++) {
            if (dfn[i] == -1) {
                top = 0;
                DFS(i,i);
            }
        }
        for(int i=0;i<nScc;i++) res.pb(sccv[i]);
        return res;
    }
}graph;
```

9.7 MaxClique

```
class MaxClique {
    public:
    static const int MV = 210;
    int V;
    int el[MV][MV/30+1];
    int dp[MV];
    int ans;
    int s[MV][MV/30+1];
    vector<int> sol;
    void init(int v) {
        V = v; ans = 0;
        MEMS(el); MEMS(dp);
    }
    /* Zero Base */
    void addEdge(int u, int v) {
        if(u > v) swap(u, v);
        if(u == v) return;
        el[u][v/32] |= (1<<(v%32));
    }
    bool dfs(int v, int k) {
        int c = 0, d = 0;
        for(int i=0; i<(V+31)/32; i++) {
            s[k][i] = el[v][i];
            if(k != 1) s[k][i] &= s[k-1][i];
            c += __builtin_popcount(s[k][i]);
        }
        if(c == 0) {
            if(k > ans) {
                ans = k;
                sol.clear();
                sol.push_back(v);
                return 1;
            }
            return 0;
        }
        for(int i=0; i<(V+31)/32; i++) {
            for(int a = s[k][i]; a ; d++) {
                if(k + (c-d) <= ans) return 0;
                int lb = a&(-a), lg = 0;
                a ^= lb;
                while(lb!=1) {
                    lb = (unsigned int)(lb) >> 1;
                    lg ++;
                }
                int u = i*32 + lg;
                if(k + dp[u] <= ans) return 0;
                if(dfs(u, k+1)) {
                    sol.push_back(v);
                    return 1;
                }
            }
        }
        return 0;
    }
    int solve() {
        for(int i=V-1; i>=0; i--) {
            dfs(i, 1);
            dp[i] = ans;
        }
        return ans;
    }
};
```

9.8 BCCedge

```
vector<vector<int> > v;
int vis[100005],lwn[100005];
vector<int> stk;
int f[100005];
int bln[100005];
int Find(int a){
  if(bln[a]==a)return a;
  return bln[a]=Find(bln[a]);
}
int t;
void dfs(int a,int p){
  stk.pb(a);
  bln[a]=a;
  vis[a]=lwn[a]=++t;
  int cnt=0;
  for(int i=0;i<v[a].size();i++){
    int x=v[a][i];
    if(x!=p||cnt==1){
      if(vis[x]==0){
        dfs(x,a);
        if(lwn[x]>vis[a]){
          int fa=Find(x);
          f[x]=Find(a);
          while(stk.back()!=x){
            bln[stk.back()]=fa;
            stk.pop_back();
          }
          bln[stk.back()]=fa;
          stk.pop_back();
        }
        lwn[a]=min(lwn[a],lwn[x]);
      }
      else{
        lwn[a]=min(lwn[a],vis[x]);
      }
    }
    else{
      cnt++;
    }
  }
}
```

10 無權邊的生成樹個數 Kirchhoff's Theorem

1. 定義 $n \times m$ 矩陣 $E = (a_{i,j})$，n 為點數，m 為邊數，若 i 點在 j 邊上，i 為小點 $a_{i,j} = 1$，i 為大點 $a_{i,j} = -1$，否則

$a_{i,j} = 0$。
(證明省略)
4. 令 $E(E^T) = Q$，他是一種有負號的 kirchhoff 的矩陣，取 Q 的子矩陣即為 $F(F^T)$
結論：做 Q 取子矩陣算 det 即為所求。(除去第一行第一列 by mz)

11 monge

$i \leq i^{'} < j \leq j^{'}$
$m(i,j) + m(i^{'}, j^{'}) \leq m(i^{'}, j) + m(i, j^{'})$
$k(i, j-1) <= k(i,j) <= k(i+1, j)$

12 四心

$\frac{sa*A+sb*B+sc*C}{sa+sb+sc}$
外心 sin 2A : sin 2B : sin 2C
內心 sin A : sin B : sin C
垂心 tan A : tan B : tan C
重心 1 : 1 : 1

13 Runge-Kutta

$y_{n+1} = y_n + \frac{h}{6}(k_1 + 2k_2 + 2k_3 + k_4)$
$k_1 = f(t_n, y_n)$
$k_2 = f(t_n + \frac{h}{2}, y_n + \frac{h}{2}k_2)$
$k_3 = f(t_n + \frac{h}{2}, y_n + \frac{h}{2}k_3)$
$k_2 = f(t_n + h, y_n + hk_3)$

14 Householder Matrix

$I - 2\frac{vv^T}{v^Tv}$