1 Computational_Geometry

1.1 Geometry.cpp

```cpp
const double PI=atan2(0.0,-1.0);
template<typename T>
struct point{
  T x,y;
  point(){}
  point(const T&x,const T&y):x(x),y(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*(const T &b)const{
    return point(x*b,y*b); }
  point operator/(const T &b)const{
    return point(x/b,y/b); }
  bool operator==(const point &b)const{
    return x==b.x&&y==b.y; }
  T dot(const point &b)const{
    return x*b.x+y*b.y; }
  T cross(const point &b)const{
    return x*b.y-y*b.x; }
  point normal()const{//求法向量
    return point(-y,x); }
  T abs2()const{//向量長度的平方
    return dot(*this); }
  T rad(const point &b)const{//兩向量的弧度
    return fabs(atan2(fabs(cross(b)),dot(b))); }
  T getA()const{//對x軸的弧度
    T A=atan2(y,x);//超過180度會變負的
    if(A<=-PI/2)A+=PI*2;
    return A;
  }
};
template<typename T>
struct line{
  line(){}
  point<T> p1,p2;
  T a,b,c;//ax+by+c=0
  line(const point<T>&x,const point<T>&y):p1
    (x),p2(y){}
  void pton(){//轉成一般式
    a=p1.y-p2.y;
    b=p2.x-p1.x;
    c=-a*p1.x-b*p1.y;
  }
  T ori(const point<T> &p)const{//點和有向直
    線的關係,>0左邊、=0在線上<0右邊
    return (p2-p1).cross(p-p1);
  }
  T btw(const point<T> &p)const{//點投影落在
    線段上<=0
    return (p1-p).dot(p2-p);
  }
  bool point_on_segment(const point<T>&p)
    const{//點是否在線段上
    return ori(p)==0&&btw(p)<=0;
  }
```

```cpp
  T dis2(const point<T> &p,bool is_segment
    =0)const{//點跟直線/線段的距離平方
    point<T> v=p2-p1,v1=p-p1;
    if(is_segment){
      point<T> v2=p-p2;
      if(v.dot(v1)<=0)return v1.abs2();
      if(v.dot(v2)>=0)return v2.abs2();
    }
    T tmp=v.cross(v1);
    return tmp*tmp/v.abs2();
  }
  T seg_dis2(const line<T> &l)const{//兩線段
    距離平方
    return min({dis2(l.p1,1),dis2(l.p2,1),l.
      dis2(p1,1),l.dis2(p2,1)});
  }
  point<T> projection(const point<T> &p)
    const{//點對直線的投影
    point<T> n=(p2-p1).normal();
    return p-n*(p-p1).dot(n)/n.abs2();
  }
  point<T> mirror(const point<T> &p)const{
    //點對直線的鏡射,要先呼叫pton轉成一般式
    point<T> R;
    T d=a*a+b*b;
    R.x=(b*b*p.x-a*a*p.x-2*a*b*p.y-2*a*c)/d;
    R.y=(a*a*p.y-b*b*p.y-2*a*b*p.x-2*b*c)/d;
    return R;
  }
  bool equal(const line &l)const{//直線相等
    return ori(l.p1)==0&&ori(l.p2)==0;
  }
  bool parallel(const line &l)const{
    return (p1-p2).cross(l.p1-l.p2)==0;
  }
  bool cross_seg(const line &l)const{
    return (p2-p1).cross(l.p1-p1)*(p2-p1).
      cross(l.p2-p1)<=0;//直線是否交線段
  }
  int line_intersect(const line &l)const{//
    直線相交情況,-1無限多點、1交於一點、0
    不相交
    return parallel(l)?(ori(l.p1)==0?-1:0)
      :1;
  }
  int seg_intersect(const line &l)const{
    T c1=ori(l.p1), c2=ori(l.p2);
    T c3=l.ori(p1), c4=l.ori(p2);
    if(c1==0&&c2==0){//共線
      bool b1=btw(l.p1)>=0,b2=btw(l.p2)>=0;
      T a3=l.btw(p1),a4=l.btw(p2);
      if(b1&&b2&&a3>=0&&a4>=0) return 2;
      if(b1&&b2&&a3>=0&&a4>=0) return 3;
      if(b1&&b2&&a3>=0&&a4>=0) return 0;
      return -1;//無限交點
    }else if(c1*c2<=0&&c3*c4<=0)return 1;
    return 0;//不相交
  }
  point<T> line_intersection(const line &l)
    const{/*直線交點*/
    point<T> a=p2-p1,b=l.p2-l.p1,s=l.p1-p1;
    //if(a.cross(b)==0)return INF;
    return p1+a*(s.cross(b)/a.cross(b));
  }
```

```cpp
  point<T> seg_intersection(const line &l)
    const{//線段交點
    int res=seg_intersect(l);
    if(res<=0) assert(0);
    if(res==2) return p1;
    if(res==3) return p2;
    return line_intersection(l);
  }
};
template<typename T>
struct polygon{
  polygon(){}
  vector<point<T> > p;//逆時針順序
  T area()const{//面積
    T ans=0;
    for(int i=p.size()-1,j=0;j<(int)p.size()
      ;i=j++)
      ans+=p[i].cross(p[j]);
    return ans/2;
  }
  point<T> center_of_mass()const{//重心
    T cx=0,cy=0,w=0;
    for(int i=p.size()-1,j=0;j<(int)p.size()
      ;i=j++){
      T a=p[i].cross(p[j]);
      cx+=(p[i].x+p[j].x)*a;
      cy+=(p[i].y+p[j].y)*a;
      w+=a;
    }
    return point<T>(cx/3/w,cy/3/w);
  }
  char ahas(const point<T>& t)const{//點是否
    在簡單多邊形內,是的話回傳1、在邊上回
    傳-1、否則回傳0
    bool c=0;
    for(int i=0,j=p.size()-1;i<p.size();j=i
      ++)
      if(line<T>(p[i],p[j]).point_on_segment
        (t))return -1;
      else if((p[i].y>t.y)!=(p[j].y>t.y)&&
      t.x<(p[j].x-p[i].x)*(t.y-p[i].y)/(p[j
        ].y-p[i].y)+p[i].x)
        c=!c;
    return c;
  }
  char point_in_convex(const point<T>&x)
    const{
    int l=1,r=(int)p.size()-2;
    while(l<=r){//點是否在凸多邊形內,是的話
      回傳1、在邊上回傳-1、否則回傳0
      int mid=(l+r)/2;
      T a1=(p[mid]-p[0]).cross(x-p[0]);
      T a2=(p[mid+1]-p[0]).cross(x-p[0]);
      if(a1>=0&&a2<=0){
        T res=(p[mid+1]-p[mid]).cross(x-p[
          mid]);
        return res>0?1:(res>=0?-1:0);
      }else if(a1<0)r=mid-1;
      else l=mid+1;
    }
    return 0;
  }
  vector<T> getA()const{//凸包邊對x軸的夾角
    vector<T>res;//一定是遞增的
```

```cpp
    for(size_t i=0;i<p.size();++i)
      res.push_back((p[(i+1)%p.size()]-p[i])
        .getA());
    return res;
  }
  bool line_intersect(const vector<T>&A,
    const line<T> &l)const{//O(logN)
    int f1=upper_bound(A.begin(),A.end(),(l.
      p1-l.p2).getA())-A.begin();
    int f2=upper_bound(A.begin(),A.end(),(l.
      p2-l.p1).getA())-A.begin();
    return l.cross_seg(line<T>(p[f1],p[f2]))
      ;
  }
  polygon cut(const line<T> &l)const{//凸包
    對直線切割,得到直線l左側的凸包
    polygon ans;
    for(int n=p.size(),i=n-1,j=0;j<n;i=j++){
      if(l.ori(p[i])>=0){
        ans.p.push_back(p[i]);
        if(l.ori(p[j])<0)
          ans.p.push_back(l.
            line_intersection(line<T>(p[i
            ],p[j])));
      }else if(l.ori(p[j])>0)
        ans.p.push_back(l.line_intersection(
          line<T>(p[i],p[j])));
    }
    return ans;
  }
  static bool graham_cmp(const point<T>& a,
    const point<T>& b){//凸包排序函數
    return (a.x<b.x)||(a.x==b.x&&a.y<b.y);
  }
  void graham(vector<point<T> > &s){//凸包
    sort(s.begin(),s.end(),graham_cmp);
    p.resize(s.size()+1);
    int m=0;
    for(size_t i=0;i<s.size();++i){
      while(m>=2&&(p[m-1]-p[m-2]).cross(s[i
        ]-p[m-2])<=0)--m;
      p[m++]=s[i];
    }
    for(int i=s.size()-2,t=m+1;i>=0;--i){
      while(m>=t&&(p[m-1]-p[m-2]).cross(s[i
        ]-p[m-2])<=0)--m;
      p[m++]=s[i];
    }
    if(s.size()>1)--m;
    p.resize(m);
  }
  T diam(){//直徑
    int n=p.size(),t=1;
    T ans=0;p.push_back(p[0]);
    for(int i=0;i<n;i++){
      point<T> now=p[i+1]-p[i];
      while(now.cross(p[t+1]-p[i])>now.cross
        (p[t]-p[i]))t=(t+1)%n;
      ans=max(ans,(p[i]-p[t]).abs2());
    }
    return p.pop_back(),ans;
  }
  T min_cover_rectangle(){//最小覆蓋矩形
    int n=p.size(),t=1,r=1,l;
```

```cpp
    if(n<3)return 0;//也可以做最小周長矩形
    T ans=1e99;p.push_back(p[0]);
    for(int i=0;i<n;i++){
        point<T> now=p[i+1]-p[i];
        while(now.cross(p[t+1]-p[i])>now.cross
            (p[t]-p[i]))t=(t+1)%n;
        while(now.dot(p[r+1]-p[i])>now.dot(p[r
            ]-p[i]))r=(r+1)%n;
        if(!i)l=r;
        while(now.dot(p[l+1]-p[i])<=now.dot(p[
            l]-p[i]))l=(l+1)%n;
        T d=now.abs2();
        T tmp=now.cross(p[t]-p[i])*(now.dot(p[
            r]-p[i])-now.dot(p[l]-p[i]))/d;
        ans=min(ans,tmp);
    }
    return p.pop_back(),ans;
}
T max_triangle(){//最大內接三角形
    int n=p.size(),a=1,b=2;
    if(n<3)return 0;
    T ans=0,tmp;p.push_back(p[0]);
    for(int i=0;i<n;++i){
        while((p[a]-p[i]).cross(p[b+1]-p[i])>(
            tmp=(p[a]-p[i]).cross(p[b]-p[i])))
            b=(b+1)%n;
        ans=max(ans,tmp);
        while((p[a+1]-p[i]).cross(p[b]-p[i])>(
            tmp=(p[a]-p[i]).cross(p[b]-p[i])))
            a=(a+1)%n;
        ans=max(ans,tmp);
    }
    return p.pop_back(),ans/2;
}
T dis2(polygon &pl){//凸包最近距離平方
    vector<point<T> > &P=p,&Q=pl.p;
    int n=P.size(),m=Q.size(),l=0,r=0;
    for(int i=0;i<n;++i)if(P[i].y<P[l].y)l=i;
    for(int i=0;i<m;++i)if(Q[i].y<Q[r].y)r=i;
    P.push_back(P[0]),Q.push_back(Q[0]);
    T ans=1e99;
    for(int i=0;i<n;++i){
        while((P[l]-P[l+1]).cross(Q[r+1]-Q[r])
            <0)r=(r+1)%m;
        ans=min(ans,line<T>(P[l],P[l+1]).
            seg_dis2(line<T>(Q[r],Q[r+1])));
        l=(l+1)%n;
    }
    return P.pop_back(),Q.pop_back(),ans;
}
static char sign(const point<T>&t){
    return (t.y==0?t.x:t.y)<0;
}
static bool angle_cmp(const line<T>& A,
    const line<T>& B){
    point<T> a=A.p2-A.p1,b=B.p2-B.p1;
    return sign(a)<sign(b)||(sign(a)==sign(b
        )&&a.cross(b)>0);
}
int halfplane_intersection(vector<line<T>
    > &s){//半平面交
    sort(s.begin(),s.end(),angle_cmp);//線段
        左側為該線段半平面
    int L,R,n=s.size();
    vector<point<T> > px(n);
```

```cpp
    vector<line<T> > q(n);
    q[L=R=0]=s[0];
    for(int i=1;i<n;++i){
        while(L<R&&s[i].ori(px[R-1])<=0)--R;
        while(L<R&&s[i].ori(px[L])<=0)++L;
        q[++R]=s[i];
        if(q[R].parallel(q[R-1])){
            --R;
            if(q[R].ori(s[i].p1)>0)q[R]=s[i];
        }
        if(L<R)px[R-1]=q[R-1].
            line_intersection(q[R]);
    }
    while(L<R&&q[L].ori(px[R-1])<=0)--R;
    p.clear();
    if(R-L<=1)return 0;
    px[R]=q[R].line_intersection(q[L]);
    for(int i=L;i<=R;++i)p.push_back(px[i]);
    return R-L+1;
}
};
template<typename T>
struct triangle{
    point<T> a,b,c;
    triangle(){}
    triangle(const point<T> &a,const point<T>
        &b,const point<T> &c):a(a),b(b),c(c){}
    T area(){
        T t=(b-a).cross(c-a)/2;
        return t>0?t:-t;
    }
    point<T> barycenter()const{//重心
        return (a+b+c)/3;
    }
    point<T> circumcenter()const{//外心
        static line<T> u,v;
        u.p1=(a+b)/2;
        u.p2=point<T>(u.p1.x-a.y+b.y,u.p1.y+a.x-
            b.x);
        v.p1=(a+c)/2;
        v.p2=point<T>(v.p1.x-a.y+c.y,v.p1.y+a.x-
            c.x);
        return u.line_intersection(v);
    }
    point<T> incenter()const{//內心
        T A=sqrt((b-c).abs2()),B=sqrt((a-c).abs2
            ()),C=sqrt((a-b).abs2());
        return point<T>(A*a.x+B*b.x+C*c.x,A*a.y+
            B*b.y+C*c.y)/(A+B+C);
    }
    point<T> perpencenter()const{//垂心
        return barycenter()*3-circumcenter()*2;
    }
};
template<typename T>
struct point3D{
    T x,y,z;
    point3D(){}
    point3D(const T&x,const T&y,const T&z):x(x
        ),y(y),z(z){}
    point3D operator+(const point3D &b)const{
        return point3D(x+b.x,y+b.y,z+b.z);}
    point3D operator-(const point3D &b)const{
        return point3D(x-b.x,y-b.y,z-b.z);}
    point3D operator*(const T &b)const{
```

```cpp
        return point3D(x*b,y*b,z*b);}
    point3D operator/(const T &b)const{
        return point3D(x/b,y/b,z/b);}
    bool operator==(const point3D &b)const{
        return x==b.x&&y==b.y&&z==b.z;}
    T dot(const point3D &b)const{
        return x*b.x+y*b.y+z*b.z;}
    point3D cross(const point3D &b)const{
        return point3D(y*b.z-z*b.y,z*b.x-x*b.z,x
            *b.y-y*b.x);}
    T abs2()const{//向量長度的平方
        return dot(*this);}
    T area2(const point3D &b)const{//和b、原點
        圍成面積的平方
        return cross(b).abs2()/4;}
};
template<typename T>
struct line3D{
    point3D<T> p1,p2;
    line3D(){}
    line3D(const point3D<T> &p1,const point3D<
        T> &p2):p1(p1),p2(p2){}
    T dis2(const point3D<T> &p,bool is_segment
        =0)const{//點跟直線/線段的距離平方
        point3D<T> v=p2-p1,v1=p-p1;
        if(is_segment){
            point3D<T> v2=p-p2;
            if(v.dot(v1)<=0)return v1.abs2();
            if(v.dot(v2)>=0)return v2.abs2();
        }
        point3D<T> tmp=v.cross(v1);
        return tmp.abs2()/v.abs2();
    }
    pair<point3D<T>,point3D<T> > closest_pair(
        const line3D<T> &l)const{
        point3D<T> v1=(p1-p2),v2=(l.p1-l.p2);
        point3D<T> N=v1.cross(v2),ab(p1-l.p1);
        //if(N.abs2()==0)return NULL;平行或重合
        T tmp=N.dot(ab),ans=tmp*tmp/N.abs2();//
            最近點對距離
        point3D<T> d1=p2-p1,d2=l.p2-l.p1,D=d1.
            cross(d2),G=l.p1-p1;
        T t1=(G.cross(d2)).dot(D)/D.abs2();
        T t2=(G.cross(d1)).dot(D)/D.abs2();
        return make_pair(p1+d1*t1,l.p1+d2*t2);
    }
    bool same_side(const point3D<T> &a,const
        point3D<T> &b)const{
        return (p2-p1).cross(a-p1).dot((p2-p1).
            cross(b-p1))>0;
    }
};
template<typename T>
struct plane{
    point3D<T> p0,n;//平面上的點和法向量
    plane(){}
    plane(const point3D<T> &p0,const point3D<T
        > &n):p0(p0),n(n){}
    T dis2(const point3D<T> &p)const{//點到平
        面距離的平方
        T tmp=(p-p0).dot(n);
        return tmp*tmp/n.abs2();
    }
```

```cpp
    point3D<T> projection(const point3D<T> &p)
        const{
        return p-n*(p-p0).dot(n)/n.abs2();
    }
    point3D<T> line_intersection(const line3D<
        T> &l)const{
        T tmp=n.dot(l.p2-l.p1);//等於0表示平行或
            重合該直線
        return l.p1+(l.p2-l.p1)*(n.dot(p0-l.p1)/
            tmp);
    }
    line3D<T> plane_intersection(const plane &
        pl)const{
        point3D<T> e=n.cross(pl.n),v=n.cross(e);
        T tmp=pl.n.dot(v);//等於0表示平行或重合
            該平面
        point3D<T> q=p0+(v*(pl.n.dot(pl.p0-p0))/
            tmp);
        return line3D<T>(q,q+e);
    }
};
template<typename T>
struct triangle3D{
    point3D<T> a,b,c;
    triangle3D(){}
    triangle3D(const point3D<T> &a,const
        point3D<T> &b,const point3D<T> &c):a(a
        ),b(b),c(c){}
    bool point_in(const point3D<T> &p)const{//
        點在該平面上的投影在三角形中
        return line3D<T>(b,c).same_side(p,a)&&
            line3D<T>(a,c).same_side(p,b)&&
            line3D<T>(a,b).same_side(p,c);
    }
};
template<typename T>
struct tetrahedron{//四面體
    point3D<T> a,b,c,d;
    tetrahedron(){}
    tetrahedron(const point3D<T> &a,const
        point3D<T> &b,const point3D<T> &c,
        const point3D<T> &d):a(a),b(b),c(c),d(
        d){}
    T volume6()const{//體積的六倍
        return (d-a).dot((b-a).cross(c-a));
    }
    point3D<T> centroid()const{
        return (a+b+c+d)/4;
    }
    bool point_in(const point3D<T> &p)const{
        return triangle3D<T>(a,b,c).point_in(p)
            &&triangle3D<T>(c,d,a).point_in(p);
    }
};
template<typename T>
struct convexhull3D{
    static const int MAXN=1005;
    struct face{
        int a,b,c;
        face(int a,int b,int c):a(a),b(b),c(c){}
    };
    vector<point3D<T>> pt;
    vector<face> ans;
    int fid[MAXN][MAXN];
```

```
421  void build(){
422    int n=pt.size();
423    ans.clear();
424    memset(fid,0,sizeof(fid));
425    ans.emplace_back(0,1,2);//注意不能共線
426    ans.emplace_back(2,1,0);
427    int ftop = 0;
428    for(int i=3, ftop=1; i<n; ++i,++ftop){
429      vector<face> next;
430      for(auto &f:ans){
431        T d=(pt[i]-pt[f.a]).dot((pt[f.b]-pt[
             f.a]).cross(pt[f.c]-pt[f.a]));
432        if(d<=0) next.push_back(f);
433        int ff=0;
434        if(d>0) ff=ftop;
435        else if(d<0) ff=-ftop;
436        fid[f.a][f.b]=fid[f.b][f.c]=fid[f.c
             ][f.a]=ff;
437      }
438      for(auto &f:ans){
439        if(fid[f.a][f.b]>0 && fid[f.a][f.b
             ]!=fid[f.b][f.a])
440          next.emplace_back(f.a,f.b,i);
441        if(fid[f.b][f.c]>0 && fid[f.b][f.c
             ]!=fid[f.c][f.b])
442          next.emplace_back(f.b,f.c,i);
443        if(fid[f.c][f.a]>0 && fid[f.c][f.a
             ]!=fid[f.a][f.c])
444          next.emplace_back(f.c,f.a,i);
445      }
446      ans=next;
447    }
448  }
449  point3D<T> centroid()const{
450    point3D<T> res(0,0,0);
451    T vol=0;
452    for(auto &f:ans){
453      T tmp=pt[f.a].dot(pt[f.b].cross(pt[f.c
             ]));
454      res=res+(pt[f.a]+pt[f.b]+pt[f.c])*tmp;
455      vol+=tmp;
456    }
457    return res/(vol*4);
458  }
459 };
```

1.2 SmallestCircle.cpp

```
1  #include"Geometry.cpp"
2  struct Circle{
3    typedef point<double> p;
4    typedef const point<double> cp;
5    p x;
6    double r2;
7    bool incircle(cp &c)const{return (x-c).
           abs2()<=r2;}
8  };
9
10 Circle TwoPointCircle(Circle::cp &a, Circle
         ::cp &b) {
11   Circle::p m=(a+b)/2;
12   return (Circle){m,(a-m).abs2()};
13 }
```

```
14
15 Circle outcircle(Circle::p a, Circle::p b,
         Circle::p c) {
16   if(TwoPointCircle(a,b).incircle(c))
17     return TwoPointCircle(a,b);
17   if(TwoPointCircle(b,c).incircle(a))
       return TwoPointCircle(b,c);
18   if(TwoPointCircle(c,a).incircle(b))
       return TwoPointCircle(c,a);
19   Circle::p ret;
20   double a1=b.x-a.x, b1=b.y-a.y, c1=(a1*a1
           +b1*b1)/2;
21   double a2=c.x-a.x, b2=c.y-a.y, c2=(a2*a2
           +b2*b2)/2;
22   double d = a1*b2 - a2*b1;
23   ret.x=a.x+(c1*b2-c2*b1)/d;
24   ret.y=a.y+(a1*c2-a2*c1)/d;
25   return (Circle){ret,(ret-a).abs2()};
26 }
27 //rand required
28 Circle SmallestCircle(std::vector<Circle::p>
         &p){
29   int n=p.size();
30   if(n==1) return (Circle){p[0],0.0};
31   if(n==2) return TwoPointCircle(p[0],p
         [1]);
32   random_shuffle(p.begin(),p.end());
33   Circle c = {p[0],0.0};
34   for(int i=0;i<n;++i){
35     if(c.incircle(p[i])) continue;
36     c=Circle{p[i],0.0};
37     for(int j=0;j<i;++j){
38       if(c.incircle(p[j])) continue;
39       c=TwoPointCircle(p[i],p[j]);
40       for(int k=0;k<j;++k){
41         if(c.incircle(p[k]))
               continue;
42         c=outcircle(p[i],p[j],p[k]);
43       }
44     }
45   }
46   return c;
47 }
```

1.3 最近點對.cpp

```
1  template<typename _IT=point<T>* >
2  T cloest_pair(_IT L, _IT R){
3    if(R-L <= 1) return INF;
4    _IT mid = L+(R-L)/2;
5    T x = mid->x;
6    T d = min(cloest_pair(L,mid),cloest_pair(
           mid,R));
7    inplace_merge(L, mid, R, ycmp);
8    static vector<point> b; b.clear();
9    for(auto u=L;u<R;++u){
10     if((u->x-x)*(u->x-x)>=d) continue;
11     for(auto v=b.rbegin();v!=b.rend();++v){
12       T dx=u->x-v->x, dy=u->y-v->y;
13       if(dy*dy>=d) break;
14       d=min(d,dx*dx+dy*dy);
15     }
16     b.push_back(*u);
```

```
17   }
18   return d;
19 }
20 T closest_pair(vector<point<T>> &v){
21   sort(v.begin(),v.end(),xcmp);
22   return closest_pair(v.begin(),v.end());
23 }
```

2 Data_Structure

2.1 DLX.cpp

```
1  const int MAXN=4100, MAXM=1030, MAXND=16390;
2  struct DLX{
3    int n,m,sz,ansd;//高是n，寬是m的稀疏矩陣
4    int S[MAXM],H[MAXN];
5    int row[MAXND],col[MAXND];//每個節點代表的
           列跟行
6    int L[MAXND],R[MAXND],U[MAXND],D[MAXND];
7    vector<int> ans,anst;
8    void init(int _n,int _m){
9      n=_n,m=_m;
10     for(int i=0;i<=m;++i){
11       U[i]=D[i]=i,L[i]=i-1,R[i]=i+1;
12       S[i]=0;
13     }
14     R[m]=0,L[0]=m;
15     sz=m,ansd=INT_MAX;//ansd存最優解的個數
16     for(int i=1;i<=n;++i)H[i]=-1;
17   }
18   void add(int r,int c){
19     ++S[col[++sz]=c];
20     row[sz]=r;
21     D[sz]=D[c],U[D[c]]=sz,U[sz]=c,D[c]=sz;
22     if(H[r]<0)H[r]=L[sz]=R[sz]=sz;
23     else R[sz]=R[H[r]],L[R[H[r]]]=sz,L[sz]=H
             [r],R[H[r]]=sz;
24   }
25 #define DFOR(i,A,s) for(int i=A[s];i!=s;i=
         A[i])
26   void remove(int c){//刪除第c行和所有當前覆
             蓋到第c行的列
27     L[R[c]]=L[c],R[L[c]]=R[c];//這裡刪除第c
             行，若有些行不需要處理可以在開始時呼
             叫他
28     DFOR(i,D,c)DFOR(j,R,i){U[D[j]]=U[j],D[U[
             j]]=D[j],--S[col[j]];}
29   }
30   void restore(int c){//恢復第c行和所有當前
             覆蓋到第c行的列，remove的逆操作
31     DFOR(i,U,c)DFOR(j,L,i){++S[col[j]],U[D[j
             ]]=j,D[U[j]]=j;}
32     L[R[c]]=c,R[L[c]]=c;
33   }
34   void remove2(int nd){//刪除nd所在的行當前
             所有點(包括虛擬節點)，只保留nd
35     DFOR(i,D,nd)L[R[i]]=L[i],R[L[i]]=R[i];
36   }
```

```
37   void restore2(int nd){//刪除nd所在的行當前
             所有點，為remove2的逆操作
38     DFOR(i,U,nd)L[R[i]]=R[L[i]]=i;
39   }
40   bool vis[MAXM];
41   int h(){//估價函數 for IDA*
42     int res=0;
43     memset(vis,0,sizeof(vis));
44     DFOR(i,R,0)if(!vis[i]){
45       vis[i]=1;
46       ++res;
47       DFOR(j,D,i)DFOR(k,R,j)vis[col[k]]=1;
48     }
49     return res;
50   }
51   bool dfs(int d){//for精確覆蓋問題
52     if(d+h()>=ansd)return 0;//找最佳解用，找
             任意解可以刪掉
53     if(!R[0]){ansd=d;return 1;}
54     int c=R[0];
55     DFOR(i,R,0)if(S[i]<S[c])c=i;
56     remove(c);
57     DFOR(i,D,c){
58       ans.push_back(row[i]);
59       DFOR(j,R,i)remove(col[j]);
60       if(dfs(d+1))return 1;
61       ans.pop_back();
62       DFOR(j,L,i)restore(col[j]);
63     }
64     restore(c);
65     return 0;
66   }
67   void dfs2(int d){//for最小重複覆蓋問題
68     if(d+h()>=ansd)return;
69     if(!R[0]){ansd=d;ans=anst;return;}
70     int c=R[0];
71     DFOR(i,R,0)if(S[i]<S[c])c=i;
72     DFOR(i,D,c){
73       anst.push_back(row[i]);
74       remove2(i);
75       DFOR(j,R,i)remove2(j),--S[col[j]];
76       dfs2(d+1);
77       anst.pop_back();
78       DFOR(j,L,i)restore2(j),++S[col[j]];
79       restore2(i);
80     }
81   }
82   bool exact_cover(){//解精確覆蓋問題
83     return ans.clear(), dfs(0);
84   }
85   void min_cover(){//解最小重複覆蓋問題
86     anst.clear();//暫存用，答案還是存在ans裡
87     dfs2(0);
88   }
89 #undef DFOR
90 };
```

2.2 Dynamic_KD_tree.cpp

```
1  template<typename T,size_t kd>//有kd個維度
2  struct kd_tree{
```

```cpp
 3  struct point{
 4    T d[kd];
 5    T dist(const point &x)const{
 6      T ret=0;
 7      for(size_t i=0;i<kd;++i)ret+=std::abs(
           d[i]-x.d[i]);
 8      return ret;
 9    }
10    bool operator==(const point &p){
11      for(size_t i=0;i<kd;++i)
12        if(d[i]!=p.d[i])return 0;
13      return 1;
14    }
15    bool operator<(const point &b)const{
16      return d[0]<b.d[0];
17    }
18  };
19  private:
20    struct node{
21      node *l,*r;
22      point pid;
23      int s;
24      node(const point &p):l(0),r(0),pid(p),s
             (1){}
25      ~node(){delete l,delete r;}
26      void up(){s=(l?l->s:0)+1+(r?r->s:0);}
27    }*root;
28    const double alpha,loga;
29    const T INF;//記得要給INF，表示極大值
30    int maxn;
31    struct __cmp{
32      int sort_id;
33      bool operator()(const node*x,const node*
             y)const{
34        return operator()(x->pid,y->pid);
35      }
36      bool operator()(const point &x,const
             point &y)const{
37        if(x.d[sort_id]!=y.d[sort_id])
38          return x.d[sort_id]<y.d[sort_id];
39        for(size_t i=0;i<kd;++i)
40          if(x.d[i]!=y.d[i])return x.d[i]<y.d[
               i];
41        return 0;
42      }
43    }cmp;
44    int size(node *o){return o?o->s:0;}
45    std::vector<node*> A;
46    node* build(int k,int l,int r){
47      if(l>r) return 0;
48      if(k==kd) k=0;
49      int mid=(l+r)/2;
50      cmp.sort_id = k;
51      std::nth_element(A.begin()+l,A.begin()+
             mid,A.begin()+r+1,cmp);
52      node *ret=A[mid];
53      ret->l = build(k+1,l,mid-1);
54      ret->r = build(k+1,mid+1,r);
55      ret->up();
56      return ret;
57    }
58    bool isbad(node*o){
59      return size(o->l)>alpha*o->s||size(o->r)
             >alpha*o->s;
60    }

61  void flatten(node *u,typename std::vector<
        node*>::iterator &it){
62    if(!u)return;
63    flatten(u->l,it);
64    *it=u;
65    flatten(u->r,++it);
66  }
67  void rebuild(node*&u,int k){
68    if((int)A.size()<u->s)A.resize(u->s);
69    typename std::vector<node*>::iterator it
           =A.begin();
70    flatten(u,it);
71    u=build(k,0,u->s-1);
72  }
73  bool insert(node*&u,int k,const point &x,
           int dep){
74    if(!u) return u=new node(x), dep<=0;
75    ++u->s;
76    cmp.sort_id=k;
77    if(insert(cmp(x,u->pid)?u->l:u->r,(k+1)%
           kd,x,dep-1)){
78      if(!isbad(u))return 1;
79      rebuild(u,k);
80    }
81    return 0;
82  }
83  node *findmin(node*o,int k){
84    if(!o)return 0;
85    if(cmp.sort_id==k)return o->l?findmin(o
           ->l,(k+1)%kd):o;
86    node *l=findmin(o->l,(k+1)%kd);
87    node *r=findmin(o->r,(k+1)%kd);
88    if(l&&!r)return cmp(l,o)?l:o;
89    if(!l&&r)return cmp(r,o)?r:o;
90    if(!l&&!r)return o;
91    if(cmp(l,r))return cmp(l,o)?l:o;
92    return cmp(r,o)?r:o;
93  }
94  bool erase(node *&u,int k,const point &x){
95    if(!u)return 0;
96    if(u->pid==x){
97      if(u->r);
98      else if(u->l) u->r=u->l, u->l=0;
99      else{
100       delete u;
101       return u=0, 1;
102     }
103     --u->s;
104     cmp.sort_id=k;
105     u->pid=findmin(u->r,(k+1)%kd)->pid;
106     return erase(u->r,(k+1)%kd,u->pid);
107   }
108   cmp.sort_id=k;
109   if(erase(cmp(x,u->pid)?u->l:u->r,(k+1)%
           kd,x))
110     return --u->s, 1;
111   return 0;
112 }
113 T heuristic(const T h[])const{
114   T ret=0;
115   for(size_t i=0;i<kd;++i)ret+=h[i];
116   return ret;
117 }
118 int qM;
119 std::priority_queue<std::pair<T,point > >
           pQ;

120 void nearest(node *u,int k,const point &x,
        T *h,T &mndist){
121   if(u==0||heuristic(h)>=mndist)return;
122   T dist=u->pid.dist(x),old=h[k];
123   /*mndist=std::min(mndist,dist);*/
124   if(dist<mndist){
125     pQ.push(std::make_pair(dist,u->pid));
126     if((int)pQ.size()==qM+1)
127       mndist=pQ.top().first,pQ.pop();
128   }
129   if(x.d[k]<u->pid.d[k]){
130     nearest(u->l,(k+1)%kd,x,h,mndist);
131     h[k]=std::abs(x.d[k]-u->pid.d[k]);
132     nearest(u->r,(k+1)%kd,x,h,mndist);
133   }else{
134     nearest(u->r,(k+1)%kd,x,h,mndist);
135     h[k]=std::abs(x.d[k]-u->pid.d[k]);
136     nearest(u->l,(k+1)%kd,x,h,mndist);
137   }
138   h[k]=old;
139 }
140 std::vector<point>in_range;
141 void range(node *u,int k,const point&mi,
        const point&ma){
142   if(!u)return;
143   bool is=1;
144   for(int i=0;i<kd;++i)
145     if(u->pid.d[i]<mi.d[i]||ma.d[i]<u->pid
             .d[i]){
146       is=0;break;
147     }
148   if(is)in_range.push_back(u->pid);
149   if(mi.d[k]<=u->pid.d[k])range(u->l,(k+1)
           %kd,mi,ma);
150   if(ma.d[k]>=u->pid.d[k])range(u->r,(k+1)
           %kd,mi,ma);
151 }
152 public:
153   kd_tree(const T &INF,double a=0.75):root
           (0),alpha(a),loga(log2(1.0/a)),INF(INF
           ),maxn(1){}
154   ~kd_tree(){delete root;}
155   void clear(){delete root,root=0,maxn=1;}
156   void build(int n,const point *p){
157     delete root,A.resize(maxn=n);
158     for(int i=0;i<n;++i)A[i]=new node(p[i]);
159     root=build(0,0,n-1);
160   }
161   void insert(const point &x){
162     insert(root,0,x,__lg(size(root))/loga);
163     if(root->s>maxn)maxn=root->s;
164   }
165   bool erase(const point &p){
166     bool d=erase(root,0,p);
167     if(root&&root->s<alpha*maxn)rebuild();
168     return d;
169   }
170   void rebuild(){
171     if(root)rebuild(root,0);
172     maxn=root->s;
173   }
174   T nearest(const point &x,int k){
175     qM=k;
176     T mndist=INF,h[kd]={};
177     nearest(root,0,x,h,mndist);
178     mndist=pQ.top().first;

179     pQ=std::priority_queue<std::pair<T,point
             > >();
180     return mndist;//回傳離x第k近的點的距離
181   }
182   const std::vector<point> &range(const
           point&mi,const point&ma){
183     in_range.clear();
184     range(root,0,mi,ma);
185     return in_range;//回傳介於mi到ma之間的點
               vector
186   }
187   int size(){return root?root->s:0;}
188 };
```

2.3 kd_tree_replace_segment_tr

```cpp
 1  /*kd樹代替高維線段樹*/
 2  struct node{
 3    node *l,*r;
 4    point pid,mi,ma;
 5    int s;
 6    int data;
 7    node(const point &p,int d):l(0),r(0),pid(p
           ),mi(p),ma(p),s(1),data(d),dmin(d),
           dmax(d){}
 8    void up(){
 9      mi=ma=pid;
10      s=1;
11      if(l){
12        for(int i=0;i<kd;++i){
13          mi.d[i]=min(mi.d[i],l->mi.d[i]);
14          ma.d[i]=max(ma.d[i],l->ma.d[i]);
15        }
16        s+=l->s;
17      }
18      if(r){
19        for(int i=0;i<kd;++i){
20          mi.d[i]=min(mi.d[i],r->mi.d[i]);
21          ma.d[i]=max(ma.d[i],r->ma.d[i]);
22        }
23        s+=r->s;
24      }
25    }
26    void up2(){
27      //其他懶惰標記向上更新
28    }
29    void down(){
30      //其他懶惰標記下推
31    }
32  }*root;
33
34  /*檢查區間包含用的函數*/
35  inline bool range_include(node *o,const
        point &L,const point &R){
36    for(int i=0;i<kd;++i)
37      if(L.d[i]>o->ma.d[i]||R.d[i]<o->mi.d[i])
           return 0;
38  }//只要(L,R)區間有和o的區間有交集就回傳
           true
39    return 1;
40 }
```

```cpp
41  inline bool range_in_range(node *o,const
        point &L,const point &R){
42    for(int i=0;i<kd;++i){
43      if(L.d[i]>o->mi.d[i]||o->ma.d[i]>R.d[i])
            return 0;
44    }//如果(L,R)區間完全包含o的區間就回傳true
45    return 1;
46  }
47  inline bool point_in_range(node *o,const
        point &L,const point &R){
48    for(int i=0;i<kd;++i){
49      if(L.d[i]>o->pid.d[i]||R.d[i]<o->pid.d[i
            ])return 0;
50    }//如果(L,R)區間完全包含o->pid這個點就回傳
            true
51    return 1;
52  }
53
54  /*單點修改,以單點改值為例*/
55  void update(node *u,const point &x,int data,
        int k=0){
56    if(!u)return;
57    u->down();
58    if(u->pid==x){
59      u->data=data;
60      u->up2();
61      return;
62    }
63    cmp.sort_id=k;
64    update(cmp(x,u->pid)?u->l:u->r,x,data,(k
        +1)%kd);
65    u->up2();
66  }
67
68  /*區間修改*/
69  void update(node *o,const point &L,const
        point &R,int data){
70    if(!o)return;
71    o->down();
72    if(range_in_range(o,L,R)){
73      //區間懶惰標記修改
74      o->down();
75      return;
76    }
77    if(point_in_range(o,L,R)){
78      //這個點在(L,R)區間,但是他的左右子樹不
            一定在區間中
79      //單點懶惰標記修改
80    }
81    if(o->l&&range_include(o->l,L,R))update(o
        ->l,L,R,data);
82    if(o->r&&range_include(o->r,L,R))update(o
        ->r,L,R,data);
83    o->up2();
84  }
85
86  /*區間查詢,以總和為例*/
87  int query(node *o,const point &L,const point
        &R){
88    if(!o)return 0;
89    o->down();
90    if(range_in_range(o,L,R))return o->sum;
91    int ans=0;
92    if(point_in_range(o,L,R))ans+=o->data;
93    if(o->l&&range_include(o->l,L,R))ans+=
        query(o->l,L,R);
94    if(o->r&&range_include(o->r,L,R))ans+=
        query(o->r,L,R);
95    return ans;
96  }
```

2.4 reference_point.cpp

```cpp
1  template<typename T>
2  struct _RefC{
3    T data;
4    int ref;
5    _RefC(const T&d=0):data(d),ref(0){}
6  };
7  template<typename T>
8  struct _rp{
9    _RefC<T> *p;
10   T *operator->(){return &p->data;}
11   T &operator*(){return p->data;}
12   operator _RefC<T>*(){return p;}
13   _rp &operator=(const _rp &t){
14     if(p&&!--p->ref)delete p;
15     p=t.p,p&&++p->ref;
16     return *this;
17   }
18   _rp(_RefC<T> *t=0):p(t){p&&++p->ref;}
19   _rp(const _rp &t):p(t.p){p&&++p->ref;}
20   ~_rp(){if(p&&!--p->ref)delete p;}
21  };
22  template<typename T>
23  inline _rp<T> new_rp(const T&nd){
24    return _rp<T>(new _RefC<T>(nd));
25  }
```

2.5 skew_heap.cpp

```cpp
1  node *merge(node *a,node *b){
2    if(!a||!b) return a?a:b;
3    if(b->data<a->data) swap(a,b);
4    swap(a->l,a->r);
5    a->l=merge(b,a->l);
6    return a;
7  }
```

2.6 undo_disjoint_set.cpp

```cpp
1  struct DisjointSet {
2    // save() is like recursive
3    // undo() is like return
4    int n, fa[MXN], sz[MXN];
5    vector<pair<int*,int>> h;
6    vector<int> sp;
7    void init(int tn) {
8      n=tn;
9      for (int i=0; i<n; i++) sz[fa[i]=i]=1;
```

```cpp
10     sp.clear(); h.clear();
11   }
12   void assign(int *k, int v) {
13     h.PB({k, *k});
14     *k=v;
15   }
16   void save() { sp.PB(SZ(h)); }
17   void undo() {
18     assert(!sp.empty());
19     int last=sp.back(); sp.pop_back();
20     while (SZ(h)!=last) {
21       auto x=h.back(); h.pop_back();
22       *x.F=x.S;
23     }
24   }
25   int f(int x) {
26     while (fa[x]!=x) x=fa[x];
27     return x;
28   }
29   void uni(int x, int y) {
30     x=f(x); y=f(y);
31     if (x==y) return;
32     if (sz[x]<sz[y]) swap(x, y);
33     assign(&sz[x], sz[x]+sz[y]);
34     assign(&fa[y], x);
35   }
36  }djs;
```

2.7 整體二分.cpp

```cpp
1  void totBS(int L, int R, vector<Item> M){
2    if(Q.empty()) return; //維護全域B陣列
3    if(L==R) 整個M的答案=r, return;
4    int mid = (L+R)/2;
5    vector<Item> mL, mR;
6    do_modify_B_with_divide(mid,M);
7    //讓B陣列在遞迴的時候只會保留[L~mid]的資訊
8    undo_modify_B(mid,M);
9    totBS(L,mid,mL);
10   totBS(mid+1,R,mR);
11  }
```

3 default

3.1 debug.cpp

```cpp
1  //volatile
2  #ifdef DEBUG
3  #define dbg(...) {\
4    fprintf(stderr,"%s - %d : (%s) = ",
        __PRETTY_FUNCTION__,__LINE__,#
        __VA_ARGS__);\
5    _DO(__VA_ARGS__);\
6  }
7  template<typename I> void _DO(I&&x){cerr<<x
        <<endl;}
```

```cpp
8  template<typename I,typename...T> void _DO(I
        &&x,T&&...tail){cerr<<x<<", ";_DO(tail
        ...);}
9  #else
10 #define dbg(...)
11 #endif
```

3.2 ext.cpp

```cpp
1  #include<bits/extc++.h>
2  #include<ext/pd_ds/assoc_container.hpp>
3  #include<ext/pd_ds/tree_policy.hpp>
4  using namespace __gnu_cxx;
5  using namespace __gnu_pbds;
6  template<typename T>
7  using pbds_set = tree<T,null_type,less<T>,
        rb_tree_tag,
        tree_order_statistics_node_update>;
8  template<typename T,typename U>
9  using pbds_map = tree<T,U,less<T>,
        rb_tree_tag,
        tree_order_statistics_node_update>;
10 using heap=__gnu_pbds::priority_queue<int>;
11 //s.find_by_order(1);//0 base
12 //s.order_of_key(1);
```

3.3 IncStack.cpp

```cpp
1  //Magic
2  #pragma GCC optimize "Ofast"
3  //stack resize,change esp to rsp if 64-bit
        system
4  asm("mov %0,%%esp\n" ::"g"(mem+10000000));
5  -Wl,--stack,214748364 -trigraphs
6  //linux stack resize
7  #include<sys/resource.h>
8  void increase_stack(){
9    const rlim_t ks=64*1024*1024;
10   struct rlimit rl;
11   int res=getrlimit(RLIMIT_STACK,&rl);
12   if(!res&&rl.rlim_cur<ks){
13     rl.rlim_cur=ks;
14     res=setrlimit(RLIMIT_STACK,&rl);
15   }
16  }
```

3.4 input.cpp

```cpp
1  inline int read(){
2    int x=0; bool f=0; char c=getchar();
3    while(ch<'0'||'9'<ch)f|=ch=='-',ch=getchar
        ();
4    while('0'<=ch&&ch<='9')x=x*10-'0'+ch,ch=
        getchar();
5    return f?-x:x;
6  }
```

```
7  // #!/bin/bash
8  // g++ -std=c++11 -O2 -Wall -Wextra -Wno-
       unused-result -DDEBUG $1 && ./a.out
9  //  -fsanitize=address -fsanitize=undefined
       -fsanitize=return
```

4 Flow

4.1 dinic.cpp

```
1  template<typename T>
2  struct DINIC{
3    static const int MAXN=105;
4    static const T INF=INT_MAX;
5    int n, level[MAXN], cur[MAXN];
6    struct edge{
7      int v,pre;
8      T cap,flow,r;
9      edge(int v,int pre,T cap):v(v),pre(pre),
         cap(cap),flow(0),r(cap){}
10   };
11   int g[MAXN];
12   vector<edge> e;
13   void init(int _n){
14     memset(g,-1,sizeof(int)*((n=_n)+1));
15     e.clear();
16   }
17   void add_edge(int u,int v,T cap,bool
         directed=false){
18     e.push_back(edge(v,g[u],cap));
19     g[u]=e.size()-1;
20     e.push_back(edge(u,g[v],directed?0:cap))
         ;
21     g[v]=e.size()-1;
22   }
23   int bfs(int s,int t){
24     memset(level,0,sizeof(int)*(n+1));
25     memcpy(cur,g,sizeof(int)*(n+1));
26     queue<int> q;
27     q.push(s);
28     level[s]=1;
29     while(q.size()){
30       int u=q.front();q.pop();
31       for(int i=g[u];~i;i=e[i].pre){
32         if(!level[e[i].v]&&e[i].r){
33           level[e[i].v]=level[u]+1;
34           q.push(e[i].v);
35           if(e[i].v==t)return 1;
36         }
37       }
38     }
39     return 0;
40   }
41   T dfs(int u,int t,T cur_flow=INF){
42     if(u==t)return cur_flow;
43     T df;
44     for(int &i=cur[u];~i;i=e[i].pre){
45       if(level[e[i].v]==level[u]+1&&e[i].r){
46         if(df=dfs(e[i].v,t,min(cur_flow,e[i
           ].r))){
47           e[i].flow+=df;
48           e[i^1].flow-=df;
49           e[i].r-=df;
50           e[i^1].r+=df;
51           return df;
52         }
53       }
54     }
55     return level[u]=0;
56   }
57   T dinic(int s,int t,bool clean=true){
58     if(clean){
59       for(size_t i=0;i<e.size();++i){
60         e[i].flow=0;
61         e[i].r=e[i].cap;
62       }
63     }
64     T ans=0, mf=0;
65     while(bfs(s,t))while(mf=dfs(s,t))ans+=mf
       ;
66     return ans;
67   }
68 };
```

4.2 ISAP_with_cut.cpp

```
1  template<typename T>
2  struct ISAP{
3    static const int MAXN=105;
4    static const T INF=INT_MAX;
5    int n;//點數
6    int d[MAXN],gap[MAXN],cur[MAXN];
7    struct edge{
8      int v,pre;
9      T cap,flow,r;
10     edge(int v,int pre,T cap):v(v),pre(pre),
         cap(cap),flow(0),r(cap){}
11   };
12   int g[MAXN];
13   vector<edge> e;
14   void init(int _n){
15     memset(g,-1,sizeof(int)*((n=_n)+1));
16     e.clear();
17   }
18   void add_edge(int u,int v,T cap,bool
         directed=false){
19     e.push_back(edge(v,g[u],cap));
20     g[u]=e.size()-1;
21     e.push_back(edge(u,g[v],directed?0:cap))
         ;
22     g[v]=e.size()-1;
23   }
24   T dfs(int u,int s,int t,T cur_flow=INF){
25     if(u==t)return cur_flow;
26     T tf=cur_flow,df;
27     for(int &i=cur[u];~i;i=e[i].pre){
28       if(e[i].r&&d[u]==d[e[i].v]+1){
29         df=dfs(e[i].v,s,t,min(tf,e[i].r));
30         e[i].flow+=df;
31         e[i^1].flow-=df;
32         e[i].r-=df;
33         e[i^1].r+=df;
34         if(!(tf-=df)||d[s]==n)return
           cur_flow-tf;
35       }
36     }
37     int mh=n;
38     for(int i=cur[u]=g[u];~i;i=e[i].pre){
39       if(e[i].r&&d[e[i].v]<mh)mh=d[e[i].v];
40     }
41     if(!--gap[d[u]])d[s]=n;
42     else ++gap[d[u]=++mh];
43     return cur_flow-tf;
44   }
45   T isap(int s,int t,bool clean=true){
46     memset(d,0,sizeof(int)*(n+1));
47     memset(gap,0,sizeof(int)*(n+1));
48     memcpy(cur,g,sizeof(int)*(n+1));
49     if(clean) for(size_t i=0;i<e.size();++i)
       {
50       e[i].flow=0;
51       e[i].r=e[i].cap;
52     }
53     T max_flow=0;
54     for(gap[0]=n;d[s]<n;)max_flow+=dfs(s,s,t
       );
55     return max_flow;
56   }
57   vector<int> cut_e;//最小割邊集
58   bool vis[MAXN];
59   void dfs_cut(int u){
60     vis[u]=1;//表示u屬於source的最小割集
61     for(int i=g[u];~i;i=e[i].pre)
62       if(e[i].flow<e[i].cap&&!vis[e[i].v])
           dfs_cut(e[i].v);
63   }
64   T min_cut(int s,int t){
65     T ans=isap(s,t);
66     memset(vis,0,sizeof(bool)*(n+1));
67     dfs_cut(s), cut_e.clear();
68     for(int u=0;u<=n;++u)
69       if(vis[u])for(int i=g[u];~i;i=e[i].pre
         )
70         if(!vis[e[i].v])cut_e.push_back(i);
71     return ans;
72   }
73 };
```

4.3 MinCostMaxFlow.cpp

```
1  template<typename _T>
2  struct MCMF{
3    static const int MAXN=440;
4    static const _T INF=999999999;
5    struct edge{
6      int v,pre;
7      _T cap,cost;
8      edge(int v,int pre,_T cap,_T cost):v(v),
         pre(pre),cap(cap),cost(cost){}
9    };
10   int n,S,T;
11   _T dis[MAXN],piS,ans;
12   bool vis[MAXN];
13   vector<edge> e;
14   int g[MAXN];
15   void init(int _n){
16     memset(g,-1,sizeof(int)*((n=_n)+1));
17     e.clear();
18   }
19   void add_edge(int u,int v,_T cap,_T cost,
         bool directed=false){
20     e.push_back(edge(v,g[u],cap,cost));
21     g[u]=e.size()-1;
22     e.push_back(edge(u,g[v],directed?0:cap,-
         cost));
23     g[v]=e.size()-1;
24   }
25   _T augment(int u,_T cur_flow){
26     if(u==T||!cur_flow)return ans+=piS*
         cur_flow,cur_flow;
27     vis[u]=1;
28     _T r=cur_flow,d;
29     for(int i=g[u];~i;i=e[i].pre){
30       if(e[i].cap&&!e[i].cost&&!vis[e[i].v])
         {
31         d=augment(e[i].v,min(r,e[i].cap));
32         e[i].cap-=d;
33         e[i^1].cap+=d;
34         if(!(r-=d))break;
35       }
36     }
37     return cur_flow-r;
38   }
39   bool modlabel(){
40     for(int u=0;u<=n;++u)dis[u]=INF;
41     static deque<int>q;
42     dis[T]=0,q.push_back(T);
43     while(q.size()){
44       int u=q.front();q.pop_front();
45       _T dt;
46       for(int i=g[u];~i;i=e[i].pre){
47         if(e[i^1].cap&&(dt=dis[u]-e[i].cost)
           <dis[e[i].v]){
48           if((dis[e[i].v]=dt)<=dis[q.size()?
             q.front():S]){
49             q.push_front(e[i].v);
50           }else q.push_back(e[i].v);
51         }
52       }
53     }
54     for(int u=0;u<=n;++u)
55       for(int i=g[u];~i;i=e[i].pre)
56         e[i].cost+=dis[e[i].v]-dis[u];
57     return piS+=dis[S], dis[S]<INF;
58   }
59   _T mincost(int s,int t){
60     S=s,T=t;
61     piS=ans=0;
62     while(modlabel()){
63       do memset(vis,0,sizeof(bool)*(n+1));
64       while(augment(S,INF));
65     }return ans;
66   }
67 };
```

5 Graph

5.1 Augmenting_Path.cpp

```cpp
#define MAXN1 505
#define MAXN2 505
int n1,n2;//n1個點連向n2個點
int match[MAXN2];//屬於n2的點匹配了哪個點
vector<int > g[MAXN1];//圖
bool vis[MAXN2];//是否走訪過
bool dfs(int u){
  for(size_t i=0;i<g[u].size();++i){
    int v=g[u][i];
    if(vis[v])continue;
    vis[v]=1;
    if(match[v]==-1||dfs(match[v]))
      return match[v]=u, 1;
  }
  return 0;
}
inline int max_match(){
  int ans=0;
  memset(match,-1,sizeof(int)*n2);
  for(int i=0;i<n1;++i){
    memset(vis,0,sizeof(bool)*n2);
    if(dfs(i))++ans;
  }
  return ans;
}
```

5.2 Augmenting_Path_multiple.

```cpp
#define MAXN1 1005
#define MAXN2 505
int n1,n2;//n1個點連向n2個點，其中n2個點可以
      匹配很多邊
vector<int> g[MAXN1];//圖
int c[MAXN2];//每個屬於n2點最多可以接受幾條
      匹配邊
vector<int> match_list[MAXN2];//每個屬於n2的
      點匹配了那些點
bool vis[MAXN2];//是否走訪過
bool dfs(int u){
  for(size_t i=0;i<g[u].size();++i){
    int v=g[u][i];
    if(vis[v])continue;
    vis[v]=true;
    if((int)match_list[v].size()<c[v]){
      return match_list[v].push_back(u),
        true;
    }else{
      for(size_t j=0;j<match_list[v].size()
        ;++j){
        int next_u=match_list[v][j];
        if(dfs(next_u))
          return match_list[v][j]=u, true;
      }
    }
  }
}
```

```cpp
    return false;
}
int max_match(){
  for(int i=0;i<n2;++i)match_list[i].clear()
    ;
  int cnt=0;
  for(int u=0;u<n1;++u){
    memset(vis,0,sizeof(bool)*n2);
    if(dfs(u))++cnt;
  }
  return cnt;
}
```

5.3 blossom_matching.cpp

```cpp
#define MAXN 505
vector<int>g[MAXN];
int pa[MAXN],match[MAXN],st[MAXN],S[MAXN],v[
    MAXN];
int t,n;
int lca(int x,int y){
  for(++t;;swap(x,y)){
    if(x==0)continue;
    if(v[x]==t)return x;
    v[x]=t;
    x=st[pa[match[x]]];
  }
}
#define qpush(x) q.push(x),S[x]=0
void flower(int x,int y,int l,queue<int> &q)
    {
  while(st[x]!=l){
    pa[x]=y;
    if(S[y=match[x]]==1)qpush(y);
    st[x]=st[y]=l, x=pa[y];
  }
}
bool bfs(int x){
  for(int i=1;i<=n;++i)st[i]=i;
  memset(S+1,-1,sizeof(int)*n);
  queue<int>q; qpush(x);
  while(q.size()){
    x=q.front(),q.pop();
    for(size_t i=0;i<g[x].size();++i){
      int y=g[x][i];
      if(S[y]==-1){
        pa[y]=x,S[y]=1;
        if(!match[y]){
          for(int lst;x;y=lst,x=pa[y])
            lst=match[x],match[x]=y,match[y
              ]=x;
          return 1;
        }
        qpush(match[y]);
      }else if(!S[y]&&st[y]!=st[x]){
        int l=lca(y,x);
        flower(y,x,l,q),flower(x,y,l,q);
      }
    }
  }
  return 0;
}
int blossom(){
```

5.4 graphISO.cpp

```cpp
const int MAXN=1005,K=30;//K要夠大
const long long A=3,B=11,C=2,D=19,P=0
    xdefaced;
long long f[K+1][MAXN];
vector<int> g[MAXN],rg[MAXN];
int n;
void init(){
  for(int i=0;i<n;++i){
    f[0][i]=1;
    g[i].clear(), rg[i].clear();
  }
}
void add_edge(int u,int v){
  g[u].push_back(v), rg[v].push_back(u);
}
long long point_hash(int u){//O(N)
  for(int t=1;t<=K;++t){
    for(int i=0;i<n;++i){
      f[t][i]=f[t-1][i]*A%P;
      for(int j:g[i])f[t][i]=(f[t][i]+f[t
        -1][j]*B%P)%P;
      for(int j:rg[i])f[t][i]=(f[t][i]+f[t
        -1][j]*C%P)%P;
      if(i==u)f[t][i]+=D;//如果圖太大的話，
        把這行刪掉，執行一次後f[K]就會是所
        有點的答案
      f[t][i]%=P;
    }
  }
  return f[K][u];
}
vector<long long> graph_hash(){
  vector<long long> ans;
  for(int i=0;i<n;++i)ans.push_back(
    point_hash(i));//O(N^2)
  sort(ans.begin(),ans.end());
  return ans;
}
```

5.5 KM.cpp

```cpp
#define MAXN 405
#define INF 0x3f3f3f3f
int n;// 1-base，0表示沒有匹配
int g[MAXN][MAXN],lx[MAXN],ly[MAXN],pa[MAXN
    ],slack_y[MAXN];
int match_y[MAXN],match_x[MAXN];
bool vx[MAXN],vy[MAXN];
void augment(int y){
  for(int x,z;y;y=z){
    x=pa[y],z=match_x[x];
```

```cpp
    match_y[y]=x,match_x[x]=y;
  }
}
void bfs(int st){
  for(int i=1;i<=n;++i)slack_y[i]=INF,vx[i]=
    vy[i]=0;
  queue<int> q;q.push(st);
  for(;;){
    while(q.size()){
      int x=q.front();q.pop();
      vx[x]=1;
      for(int y=1;y<=n;++y)if(!vy[y]){
        int t=lx[x]+ly[y]-g[x][y];
        if(t==0){
          pa[y]=x;
          if(!match_y[y]){augment(y);return
            ;}
          vy[y]=1,q.push(match_y[y]);
        }else if(slack_y[y]>t)pa[y]=x,
          slack_y[y]=t;
      }
    }
    int cut=INF;
    for(int y=1;y<=n;++y){
      if(!vy[y]&&cut>slack_y[y])cut=slack_y[
        y];
    }
    for(int j=1;j<=n;++j){
      if(vx[j])lx[j]-=cut;
      if(vy[j])ly[j]+=cut;
      else slack_y[j]-=cut;
    }
    for(int y=1;y<=n;++y){
      if(!vy[y]&&slack_y[y]==0){
        if(!match_y[y]){augment(y);return;}
        vy[y]=1,q.push(match_y[y]);
      }
    }
  }
}
long long KM(){
  memset(match_y,0,sizeof(int)*(n+1));
  memset(ly,0,sizeof(int)*(n+1));
  for(int x=1;x<=n;++x){
    lx[x]=-INF;
    for(int y=1;y<=n;++y)
      lx[x]=max(lx[x],g[x][y]);
  }
  for(int x=1;x<=n;++x)bfs(x);
  long long ans=0;
  for(int y=1;y<=n;++y)ans+=g[match_y[y]][y
    ];
  return ans;
}
```

5.6 MaximumClique.cpp

```cpp
struct MaxClique{
  static const int MAXN=105;
  int N,ans;
  int g[MAXN][MAXN],dp[MAXN],stk[MAXN][MAXN
    ];
```

```cpp
int sol[MAXN],tmp[MAXN];//sol[0~ans-1]為答
    案
void init(int n){
  N=n;//0-base
  memset(g,0,sizeof(g));
}
void add_edge(int u,int v){
  g[u][v]=g[v][u]=1;
}
int dfs(int ns,int dep){
  if(!ns){
    if(dep>ans){
      ans=dep;
      memcpy(sol,tmp,sizeof tmp);
      return 1;
    }else return 0;
  }
  for(int i=0;i<ns;++i){
    if(dep+ns-i<=ans)return 0;
    int u=stk[dep][i],cnt=0;
    if(dep+dp[u]<=ans)return 0;
    for(int j=i+1;j<ns;++j){
      int v=stk[dep][j];
      if(g[u][v])stk[dep+1][cnt++]=v;
    }
    tmp[dep]=u;
    if(dfs(cnt,dep+1))return 1;
  }
  return 0;
}
int clique(){
  int u,v,ns;
  for(ans=0,u=N-1;u>=0;--u){
    for(ns=0,tmp[0]=u,v=u+1;v<N;++v)
      if(g[u][v])stk[1][ns++]=v;
    dfs(ns,1),dp[u]=ans;
  }
  return ans;
}
};
```

5.7　MinimumMeanCycle.cpp

```cpp
#include<cstdint>//for DBL_MAX
int dp[maxN+1][maxN+1];
double mnc(int n){
  int u,v,w;
  const int inf=0x7f7f7f7f;
  memset(dp,0x7f,sizeof(dp));
  memset(dp[0],0,sizeof(dp[0]));
  for(int i=0;i<n;++i){
    for(auto e:E){
      tie(u,v,w)=e;
      if(dp[i][u]!=inf)
      dp[i+1][v]=min(dp[i+1][v],dp[i][u]+w);
    }
  }
  double res = DBL_MAX;
  for(int i=1;i<=n;++i){
    double val = DBL_MIN;
    for(int j=0;j<n;++j)
      val=max(val,double(dp[n][i]-dp[i][j
          ])/(n-j));
    res=min(res,val);
```

```cpp
    }
  }
  return res;
}
```

5.8　Rectilinear_MST.cpp

```cpp
//平面曼哈頓最小生成樹構造圖(去除非必要邊)
#define T int
#define INF 0x3f3f3f3f
struct point{
  T x,y;
  int id;//從0開始編號
  point(){}
  T dist(const point &p)const{
    return abs(x-p.x)+abs(y-p.y);
  }
};
bool cmpx(const point &a,const point &b){
  return a.x<b.x||(a.x==b.x&&a.y<b.y);
}
struct edge{
  int u,v;
  T cost;
  edge(int u,int v,T c):u(u),v(v),cost(c){}
  bool operator<(const edge&e)const{
    return cost<e.cost;
  }
};
struct bit_node{
  T mi;
  int id;
  bit_node(const T&mi=INF,int id=-1):mi(mi),
      id(id){}
};
vector<bit_node> bit;
void bit_update(int i,const T&data,int id){
  for(;i;i-=i&(-i)){
    if(data<bit[i].mi)bit[i]=bit_node(data,
        id);
  }
}
int bit_find(int i,int m){
  bit_node x;
  for(;i<=m;i+=i&(-i)) if(bit[i].mi<x.mi)x=
      bit[i];
  return x.id;
}
vector<edge> build_graph(int n,point p[]){
  vector<edge> e;//edge for MST
  for(int dir=0;dir<4;++dir){//4種座標變換
    if(dir%2) for(int i=0;i<n;++i) swap(p[i
        ].x,p[i].y);
    else if(dir==2) for(int i=0;i<n;++i) p[i
        ].x=-p[i].x;
    sort(p,p+n,cmpx);
    vector<T> ga(n), gb;
    for(int i=0;i<n;++i)ga[i]=p[i].y-p[i].x;
    gb=ga, sort(gb.begin(),gb.end());
    gb.erase(unique(gb.begin(),gb.end()),gb.
        end());
    int m=gb.size();
```

```cpp
    bit=vector<bit_node>(m+1);
    for(int i=n-1;i>=0;--i){
      int pos=lower_bound(gb.begin(),gb.end
          (),ga[i])-gb.begin()+1;
      int ans=bit_find(pos,m);
      if(~ans)e.push_back(edge(p[i].id,p[ans
          ].id,p[i].dist(p[ans])));
      bit_update(pos,p[i].x+p[i].y,i);
    }
  }
  return e;
}
```

5.9　treeISO.cpp

```cpp
const int MAXN=100005;
const long long X=12327,P=0xdefaced;
vector<int> g[MAXN];
bool vis[MAXN];
long long dfs(int u){//hash ver
  vis[u]=1;
  vector<long long> tmp;
  for(auto v:g[u])if(!vis[v])tmp.PB(dfs(v));
  if(tmp.empty())return 177;
  long long ret=4931;
  sort(tmp.begin(),tmp.end());
  for(auto v:tmp)ret=((ret*X)^v)%P;
  return ret;
}
//---------------------------
string dfs(int x,int p){
  vector<string> c;
  for(int y:g[x])
    if(y!=p)c.emplace_back(dfs(y,x));
  sort(c.begin(),c.end());
  string ret("(");
  for(auto &s:c)ret+=s;
  ret+=")";
  return ret;
}
```

5.10　一般圖最小權完美匹配.cpp

```cpp
struct Graph {
  // Minimum General Weighted Matching (
      Perfect Match) 0-base
  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;
    for (int i=0; i<n; i++)
      for (int j=0; j<n; j++)
        edge[i][j] = 0;
  }
  void add_edge(int u, int v, int w) {
    edge[u][v] = edge[v][u] = w;
  }
  bool SPFA(int u){
```

```cpp
    if (onstk[u]) return true;
    stk.push_back(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.push_back(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;
    }
    for(;;){
      int found = 0;
      for (int i=0; i<n; i++) dis[i] = onstk
          [i] = 0;
      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;
```

5.11　全局最小割.cpp

```cpp
const int INF=0x3f3f3f3f;
template<typename T>
struct stoer_wagner{// 0-base
  static const int MAXN=150;
  T g[MAXN][MAXN],dis[MAXN];
```

```cpp
int nd[MAXN],n,s,t;
void init(int _n){
    n=_n;
    for(int i=0;i<n;++i)
        for(int j=0;j<n;++j)g[i][j]=0;
}
void add_edge(int u,int v,T w){
    g[u][v]=g[v][u]+=w;
}
T min_cut(){
    T ans=INF;
    for(int i=0;i<n;++i)nd[i]=i;
    for(int ind,tn=n;tn>1;--tn){
        for(int i=1;i<tn;++i)dis[nd[i]]=0;
        for(int i=1;i<tn;++i){
            ind=i;
            for(int j=i;j<tn;++j){
                dis[nd[j]]+=g[nd[i-1]][nd[j]];
                if(dis[nd[ind]]<dis[nd[j]])ind=j;
            }
            swap(nd[ind],nd[i]);
        }
        if(ans>dis[nd[ind]])ans=dis[t=nd[ind
            ]],s=nd[ind-1];
        for(int i=0;i<tn;++i)
            g[nd[ind-1]][nd[i]]=g[nd[i]][nd[ind
                -1]]+=g[nd[i]][nd[ind]];
    }
    return ans;
}
};
```

5.12 平面圖判定.cpp

```cpp
static const int MAXN = 20;
struct Edge{
    int u, v;
    Edge(int s, int d) : u(s), v(d) {}
};
bool isK33(int n, int degree[]){
    int t = 0, z = 0;
    for(int i=0;i<n;++i){
        if(degree[i] == 3)++t;
        else if(degree[i] == 0)++z;
        else return false;
    }
    return t == 6 && t + z == n;
}
bool isK5(int n, int degree[]){
    int f = 0, z = 0;
    for(int i=0;i<n;++i){
        if(degree[i] == 4)++f;
        else if(degree[i] == 0)++z;
        else return false;
    }
    return f == 5 && f + z == n;
}
// it judge a given graph is Homeomorphic
    with K33 or K5
bool isHomeomorphic(bool G[MAXN][MAXN],
    const int n){
    for(;;){
        int cnt = 0;
```

```cpp
        for(int i=0;i<n;++i){
            vector<Edge> E;
            for(int j=0;j<n&&E.size()<3;++j){
                if(G[i][j] && i != j)
                    E.push_back(Edge(i, j));
            }
            if(E.size() == 1){
                G[i][E[0].v] = G[E[0].v][i] = false;
            }else if(E.size() == 2){
                G[i][E[0].v] = G[E[0].v][i] = false;
                G[i][E[1].v] = G[E[1].v][i] = false;
                G[E[0].v][E[1].v] = G[E[1].v][E[0].v
                    ] = true;
                ++cnt;
            }
        }
        if(cnt == 0)break;
    }
    static int degree[MAXN];
    fill(degree, degree + n, 0);
    for(int i=0;i<n;++i){
        for(int j=i+1; j<n; ++j){
            if(!G[i][j])continue;
            ++degree[i];
            ++degree[j];
        }
    }
    return !(isK33(n, degree) || isK5(n,
        degree));
}
```

5.13 弦圖完美消除序列.cpp

```cpp
struct chordal{
    static const int MAXN=1005;
    int n;// 0-base
    vector<int>G[MAXN];
    int rank[MAXN],label[MAXN];
    bool mark[MAXN];
    void init(int _n){n=_n;
        for(int i=0;i<n;++i)G[i].clear();
    }
    void add_edge(int u,int v){
        G[u].push_back(v);
        G[v].push_back(u);
    }
    vector<int> MCS(){
        memset(rank,-1,sizeof(int)*n);
        memset(label,0,sizeof(int)*n);
        priority_queue<pair<int,int> > pq;
        for(int i=0;i<n;++i)pq.push(make_pair(0,
            i));
        for(int i=n-1;i>=0;--i)for(;;){
            int u=pq.top().second;pq.pop();
            if(~rank[u])continue;
            rank[u]=i;
            for(auto v:G[u])if(rank[v]==-1){
                pq.push(make_pair(++label[v],v));
            }
            break;
        }
        vector<int> res(n);
        for(int i=0;i<n;++i)res[rank[i]]=i;
        return res;
```

```cpp
    }
    bool check(vector<int> ord){//弦圖判定
        for(int i=0;i<n;++i)rank[ord[i]]=i;
        memset(mark,0,sizeof(bool)*n);
        for(int i=0;i<n;++i){
            vector<pair<int,int> > tmp;
            for(auto u:G[ord[i]])if(!mark[u])
                tmp.push_back(make_pair(rank[u],u));
            sort(tmp.begin(),tmp.end());
            if(tmp.size()){
                int u=tmp[0].second;
                set<int> S;
                for(auto v:G[u])S.insert(v);
                for(size_t j=1;j<tmp.size();++j)
                    if(!S.count(tmp[j].second))return
                        0;
            }
            mark[ord[i]]=1;
        }
        return 1;
    }
};
```

5.14 最小斯坦納樹 DP.cpp

```cpp
//n個點，其中r個要構成斯坦納樹
//答案在max(dp[(1<<r)-1][k]) k=0~n-1
//p表示要構成斯坦納樹的點集
//O( n^3 + n*3^r + n^2*2^r )
#define REP(i,n) for(int i=0;i<(int)n;++i)
const int MAXN=30,MAXM=8;// 0-base
const int INF=0x3f3f3f3f;
int dp[1<<MAXM][MAXN];
int g[MAXN][MAXN];//圖
void init(){memset(g,0x3f,sizeof(g));}
void add_edge(int u,int v,int w){
    g[u][v]=g[v][u]=min(g[v][u],w);
}
void steiner(int n,int r,int *p){
    REP(k,n)REP(i,n)REP(j,n)
        g[i][j]=min(g[i][j],g[i][k]+g[k][j]);
    REP(i,n)g[i][i]=0;
    REP(i,r)REP(j,n)dp[1<<i][j]=g[p[i]][j];
    for(int i=1;i<(1<<r);++i){
        if(!(i&(i-1)))continue;
        REP(j,n)dp[i][j]=INF;
        REP(j,n){
            int tmp=INF;
            for(int s=i&(i-1);s;s=i&(s-1))
                tmp=min(tmp,dp[s][j]+dp[i^s][j]);
            REP(k,n)dp[i][k]=min(dp[i][k],g[j][k]+
                tmp);
        }
    }
}
```

5.15 最小樹形圖 __ 朱劉.cpp

```cpp
template<typename T>
struct zhu_liu{
    static const int MAXN=110,MAXM=10005;
    struct node{
        int u,v;
        T w,tag;
        node *l,*r;
        node(int u=0,int v=0,T 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];//靜態記憶體
    node *pq[MAXN*2],*E[MAXN*2];
    int st[MAXN*2],id[MAXN*2],m;
    void init(int n){
        for(int i=1;i<=n;++i){
            pq[i]=E[i]=0, st[i]=id[i]=i;
        }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);
        swap(a->l,a->r);
        a->l=merge(b,a->l);
        return a;
    }
    void add_edge(int u,int v,T 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);
    }
    T build(int root,int n){
        T 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;
            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;
        }
```

```
60    return all==1?ans:-INT_MAX;//圖不連通就
          無解
61  }
62 };
```

5.16 穩定婚姻模板.cpp

```
1 queue<int> Q;
2 for ( i : 所有考生 ) {
3    設定在第0志願;
4    Q.push(考生i);
5 }
6 while(Q.size()){
7    當前考生=Q.front();Q.pop();
8    while ( 此考生未分發 ) {
9       指標移到下一志願;
10      if ( 已經沒有志願 or 超出志願總數 )
           break;
11      計算該考生在該科系加權後的總分;
12      if ( 不符合科系需求 ) continue;
13      if ( 目前科系有餘額 ) {
14         依加權後分數高低順序將考生id加入科系錄
             取名單中;
15         break;
16      }
17      if ( 目前科系已額滿 ) {
18         if ( 此考生成績比最低分數還高 ) {
19            依加權後分數高低順序將考生id加入科系
                錄取名單;
20            Q.push(被踢出的考生);
21         }
22      }
23   }
24 }
```

6 language

6.1 CNF.cpp

```
1 #define MAXN 55
2 struct CNF{
3    int s,x,y;//s->xy | s->x, if y==-1
4    int cost;
5    CNF(){}
6    CNF(int s,int x,int y,int c):s(s),x(x),y(y
       ),cost(c){}
7 };
8 int state;//規則數量
9 map<char,int> rule;//每個字元對應到的規則,
      小寫字母為終端字符
10 vector<CNF> cnf;
11 void init(){
12    state=0;
13    rule.clear();
```

```
14    cnf.clear();
15 }
16 void add_to_cnf(char s,const string &p,int
      cost){
17    //加入一個s -> <p>的文法,代價為cost
18    if(rule.find(s)==rule.end())rule[s]=state
        ++;
19    for(auto c:p)if(rule.find(c)==rule.end())
        rule[c]=state++;
20    if(p.size()==1){
21       cnf.push_back(CNF(rule[s],rule[p[0]],-1,
           cost));
22    }else{
23       int left=rule[s];
24       int sz=p.size();
25       for(int i=0;i<sz-2;++i){
26          cnf.push_back(CNF(left,rule[p[i]],
              state,0));
27          left=state++;
28       }
29       cnf.push_back(CNF(left,rule[p[sz-2]],
           rule[p[sz-1]],cost));
30    }
31 }
32 vector<long long> dp[MAXN][MAXN];
33 vector<bool> neg_INF[MAXN][MAXN];//如果花費
      是負的可能會有無限小的情形
34 void relax(int l,int r,const CNF &c,long
      long cost,bool neg_c=0){
35    if(!neg_INF[l][r][c.s]&&(neg_INF[l][r][c.x
        ]||cost<dp[l][r][c.s])){
36       if(neg_c||neg_INF[l][r][c.x]){
37          dp[l][r][c.s]=0;
38          neg_INF[l][r][c.s]=true;
39       }else dp[l][r][c.s]=cost;
40    }
41 }
42 void bellman(int l,int r,int n){
43    for(int k=1;k<=state;++k)
44       for(auto c:cnf)
45          if(c.y==-1)relax(l,r,c,dp[l][r][c.x]+c
              .cost,k==n);
46 }
47 void cyk(const vector<int> &tok){
48    for(int i=0;i<(int)tok.size();++i){
49       for(int j=0;j<(int)tok.size();++j){
50          dp[i][j]=vector<long long>(state+1,
              INT_MAX);
51          neg_INF[i][j]=vector<bool>(state+1,
              false);
52       }
53       dp[i][i][tok[i]]=0;
54       bellman(i,i,tok.size());
55    }
56    for(int r=1;r<(int)tok.size();++r){
57       for(int l=r-1;l>=0;--l){
58          for(int k=1;k<r;++k)
59             for(auto c:cnf)
60                if(~c.y)relax(l,r,c,dp[l][k][c.x]+
                   dp[k+1][r][c.y]+c.cost);
61          bellman(l,r,tok.size());
62       }
63    }
64 }
```

7 Linear_Programming

7.1 最大密度子圖.cpp

```
1 typedef double T;//POJ 3155
2 const int MAXN=105;
3 struct edge{
4    int u,v;
5    T w;
6    edge(int u=0,int v=0,T w=0):u(u),v(v),w(w)
       {}
7 };
8 vector<edge> E;
9 int n,m;// 1-base
10 T de[MAXN],pv[MAXN];//每個點的邊權和和點權(
      有些題目會給)
11 void init(){
12    E.clear();
13    for(int i=1;i<=n;++i)de[i]=pv[i]=0;
14 }
15 void add_edge(int u,int v,T w){
16    E.push_back(edge(u,v,w));
17    de[u]+=w,de[v]+=w;
18 }
19 T U;//二分搜的最大值
20 void get_U(){
21    U=0;
22    for(int i=1;i<=n;++i)U+=2*pv[i];
23    for(size_t i=0;i<E.size();++i)U+=E[i].w;
24 }
25 ISAP<T> isap;//網路流
26 int s,t;//原匯點
27 void build(T L){
28    isap.init(n+2);
29    for(size_t i=0;i<E.size();++i)
30       isap.add_edge(E[i].u,E[i].v,E[i].w);
31    for(int v=1;v<=n;++v){
32       isap.add_edge(s,v,U);
33       isap.add_edge(v,t,U+2*L-de[v]-2*pv[v]);
34    }
35 }
36 int main(){
37    while(~scanf("%d%d",&n,&m)){
38       if(!m){
39          puts("1\n1");
40          continue;
41       }
42       init();
43       int u,v;
44       for(int i=0;i<m;++i){
45          scanf("%d%d",&u,&v);
46          add_edge(u,v,1);
47       }
48       get_U();
49       s=n+1,t=n+2;
50       T l=0,U=U,k=1.0/(n*n);
51       while(r-l>k){//二分搜最大值
52          T mid=(l+r)/2;
53          build(mid);
54          T res=(U*n-isap.isap(s,t))/2;
55          if(res>0)l=mid;
56          else r=mid;
```

```
57       }
58       build(l);
59       isap.min_cut(s,t);
60       vector<int> ans;
61       for(int i=1;i<=n;++i)
62          if(isap.vis[i])ans.push_back(i);
63       printf("%d\n",ans.size());
64       for(size_t i=0;i<ans.size();++i)
65          printf("%d\n",ans[i]);
66    }
67    return 0;
68 }
```

8 Number_Theory

8.1 basic.cpp

```
1 template<typename T>
2 void gcd(const T &a,const T &b,T &d,T &x,T &
      y){
3    if(!b) d=a,x=1,y=0;
4    else gcd(b,a%b,d,y,x), y-=x*(a/b);
5 }
6 long long int phi[N+1];
7 void phiTable(){
8    for(int i=1;i<=N;i++)phi[i]=i;
9    for(int i=1;i<=N;i++)for(x=i*2;x<=N;x+=i)
10       phi[x]-=phi[i];
10 }
11 void all_divdown(const LL &n) {// all n/x
12    for(LL a=1;a<=n;a=n/(n/(a+1))){
13       // dosomething;
14    }
15 }
16 const int MAXPRIME = 1000000;
17 int iscom[MAXPRIME], prime[MAXPRIME],
      primecnt;
18 int phi[MAXPRIME], mu[MAXPRIME];
19 void sieve(void){
20    memset(iscom,0,sizeof(iscom));
21    primecnt = 0;
22    phi[1] = mu[1] = 1;
23    for(int i=2;i<MAXPRIME;++i) {
24       if(!iscom[i]) {
25          prime[primecnt++] = i;
26          mu[i] = -1;
27          phi[i] = i-1;
28       }
29       for(int j=0;j<primecnt;++j) {
30          int k = i * prime[j];
31          if(k>=MAXPRIME) break;
32          iscom[k] = prime[j];
33          if(i%prime[j]==0) {
34             mu[k] = 0;
35             phi[k] = phi[i] * prime[j];
36             break;
37          } else {
38             mu[k] = -mu[i];
39             phi[k] = phi[i] * (prime[j]-1);
40          }
41       }
```

```
42    }
43  }
44
45  bool g_test(const LL &g, const LL &p, const
          vector<LL> &v) {
46    for(int i=0;i<v.size();++i)
47      if(modexp(g,(p-1)/v[i],p)==1)
48        return false;
49    return true;
50  }
51  LL primitive_root(const LL &p) {
52    if(p==2) return 1;
53    vector<LL> v;
54    Factor(p-1,v);
55    v.erase(unique(v.begin(), v.end()), v.end
          ());
56    for(LL g=2;g<p;++g)
57      if(g_test(g,p,v))
58        return g;
59    puts("primitive_root NOT FOUND");
60    return -1;
61  }
62  int Legendre(const LL &a, const LL &p) {
63      return modexp(a%p,(p-1)/2,p); }
64  LL inv(const LL &a, const LL &n) {
65    LL d,x,y;
66    gcd(a,n,d,x,y);
67    return d==1 ? (x+n)%n : -1;
68  }
69
70  int inv[maxN];
71  LL invtable(int n,LL P){
72    inv[1]=1;
73    for(int i=2;i<n;++i)
74      inv[i]=(P-(P/i))*inv[P%i]%P;
75  }
76
77  LL log_mod(const LL &a, const LL &b, const
          LL &p) {
78    // a ^ x = b ( mod p )
79    int m=sqrt(p+.5), e=1;
80    LL v=inv(modexp(a,m,p), p);
81    map<LL,int> x;
82    x[1]=0;
83    for(int i=1;i<m;++i) {
84      e = LLmul(e,a,p);
85      if(!x.count(e)) x[e] = i;
86    }
87    for(int i=0;i<m;++i) {
88      if(x.count(b)) return i*m + x[b];
89      b = LLmul(b,v,p);
90    }
91    return -1;
92  }
93
94  LL Tonelli_Shanks(const LL &n, const LL &p)
          {
95    // x^2 = n ( mod p )
96    if(n==0) return 0;
97    if(Legendre(n,p)!=1) while(1) { puts("SQRT
          ROOT does not exist"); }
98    int S = 0;
99    LL Q = p-1;
100   while( !(Q&1) ) { Q>>=1; ++S; }
101   if(S==1) return modexp(n%p,(p+1)/4,p);
```

```
102   LL z = 2;
103   for(;Legendre(z,p)!=-1;++z)
104     LL c = modexp(z,Q,p);
105   LL R = modexp(n%p,(Q+1)/2,p), t = modexp(n
          %p,Q,p);
106   int M = S;
107   while(1) {
108     if(t==1) return R;
109     LL b = modexp(c,1L<<(M-i-1),p);
110     R = LLmul(R,b,p);
111     t = LLmul( LLmul(b,b,p), t, p);
112     c = LLmul(b,b,p);
113     M = i;
114   }
115   return -1;
116  }
117
118  template<typename T>
119  T Euler(T n){
120    T ans=n;
121    for(T i=2;i*i<=n;++i){
122      if(n%i==0){
123        ans=ans/i*(i-1);
124        while(n%i==0)n/=i;
125      }
126    }
127    if(n>1)ans=ans/n*(n-1);
128    return ans;
129  }
130
131  //Chinese_remainder_theorem
132  template<typename T>
133  T pow_mod(T n,T k,T m){
134    T ans=1;
135    for(n=(n>=m?n%m:n);k;k>>=1){
136      if(k&1)ans=ans*n%m;
137      n=n*n%m;
138    }
139    return ans;
140  }
141  template<typename T>
142  T crt(vector<T> &m,vector<T> &a){
143    T M=1,tM,ans=0;
144    for(int i=0;i<(int)m.size();++i)M*=m[i];
145    for(int i=0;i<(int)a.size();++i){
146      tM=M/m[i];
147      ans=(ans+(a[i]*tM%M)*pow_mod(tM,Euler(m[
            i])-1,m[i])%M)%M;
148      /*如果m[i]是質數，Euler(m[i])-1=m[i]-2，
              就不用算Euler了*/
149    }
150    return ans;
151  }
152
153  //java code
154  //求sqrt(N)的連分數
155  public static void Pell(int n){
156    BigInteger N,p1,p2,q1,q2,a0,a1,a2,g1,g2,h1
            ,h2,p,q;
157    g1=q2=p1=BigInteger.ZERO;
158    h1=q1=p2=BigInteger.ONE;
159    a0=a1=BigInteger.valueOf((int)Math.sqrt
            (1.0*n));
160    BigInteger ans=a0.multiply(a0);
161    if(ans.equals(BigInteger.valueOf(n))){
```

```
162      System.out.println("No solution!");
163      return ;
164    }
165    while(true){
166      g2=a1.multiply(h1).substract(g1);
167      h2=N.substract(g2.pow(2)).divide(h1);
168      a2=g2.add(a0).divide(h2);
169      p=a1.multiply(p2).add(p1);
170      q=a1.multiply(q2).add(q1);
171      if(p.pow(2).substract(N.multiply(q.pow
              (2))).compareTo(BigInteger.ONE)==0)
                break;
172      g1=g2;h1=h2;a1=a2;
173      p1=p2;p2=p;
174      q1=q2;q2=q;
175    }
176    System.out.println(p+" "+q);
177  }
```

8.2 bit_set.cpp

```
1  void sub_set(int S){
2    int sub=S;
3    do{
4      //對某集合的子集合的處理
5      sub=(sub-1)&S;
6    }while(sub!=S);
7  }
8  void k_sub_set(int k,int n){
9    int comb=(1<<k)-1,S=1<<n;
10   while(comb<S){
11     //對大小為k的子集合的處理
12     int x=comb&-comb,y=comb+x;
13     comb=((comb&~y)/x>>1)|y;
14   }
15  }
```

8.3 cantor_expansion.cpp

```
1  int factorial[MAXN];
2  void init(){
3    factorial[0]=1;
4    for(int i=1;i<=MAXN;++i)factorial[i]=
            factorial[i-1]*i;
5  }
6  int encode(const vector<int> &s){
7    int n=s.size(),res=0;
8    for(int i=0;i<n;++i){
9      int t=0;
10     for(int j=i+1;j<n;++j)
11       if(s[j]<s[i])++t;
12     res+=t*factorial[n-i-1];
13   }
14   return res;
15  }
16  vector<int> decode(int a,int n){
17    vector<int> res;
18    vector<bool> vis(n,0);
19    for(int i=n-1;i>=0;--i){
```

```
20      int t=a/factorial[i],j;
21      for(j=0;j<n;++j)
22        if(!vis[j]){
23          if(t==0)break;
24          --t;
25        }
26      res.push_back(j);
27      vis[j]=1;
28      a%=factorial[i];
29    }
30    return res;
31  }
```

8.4 FFT.cpp

```
1  template<typename T,typename VT=vector<
          complex<T> > >
2  struct FFT{
3    const T pi;
4    FFT(const T pi=acos((T)-1)):pi(pi){}
5    unsigned bit_reverse(unsigned a,int len){
6      a=((a&0x55555555U)<<1)|((a&0xAAAAAAAAU)
              >>1);
7      a=((a&0x33333333U)<<2)|((a&0xCCCCCCCCU)
              >>2);
8      a=((a&0x0F0F0F0FU)<<4)|((a&0xF0F0F0F0U)
              >>4);
9      a=((a&0x00FF00FFU)<<8)|((a&0xFF00FF00U)
              >>8);
10     a=((a&0x0000FFFFU)<<16)|((a&0xFFFF0000U)
              >>16);
11     return a>>(32-len);
12   }
13   void fft(bool is_inv,VT &in,VT &out,int N)
              {
14     int bitlen=__lg(N),num=is_inv?-1:1;
15     for(int i=0;i<N;++i)out[bit_reverse(i,
              bitlen)]=in[i];
16     for(int step=2;step<=N;step<<=1){
17       const int mh=step>>1;
18       for(int i=0;i<mh;++i){
19         complex<T> wi=exp(complex<T>(0,i*num
                  *pi/mh));
20         for(int j=i;j<N;j+=step){
21           int k=j+mh;
22           complex<T> u=out[j],t=wi*out[k];
23           out[j]=u+t;
24           out[k]=u-t;
25         }
26       }
27     }
28     if(is_inv)for(int i=0;i<N;++i)out[i]/=N;
29   }
30  };
```

8.5 find_real_root.cpp

```
1  // an*x^n + ... + a1x + a0 = 0;
2  int sign(double x){
3    return x < -eps ? -1 : x > eps;
```

```cpp
4  }
5  double get(const vector<double>&coef, double
       x){
6    double e = 1, s = 0;
7    for(auto i : coef) s += i*e, e *= x;
8    return s;
9  }
10
11 double find(const vector<double>&coef, int n
       , double lo, double hi){
12   double sign_lo, sign_hi;
13   if( !(sign_lo = sign(get(coef,lo))) )
         return lo;
14   if( !(sign_hi = sign(get(coef,hi))) )
         return hi;
15   if(sign_lo * sign_hi > 0) return INF;
16   for(int stp = 0; stp < 100 && hi - lo >
         eps; ++stp){
17     double m = (lo+hi)/2.0;
18     int sign_mid = sign(get(coef,m));
19     if(!sign_mid) return m;
20     if(sign_lo*sign_mid < 0) hi = m;
21     else lo = m;
22   }
23   return (lo+hi)/2.0;
24 }
25
26 vector<double> cal(vector<double>coef, int n
       ){
27   vector<double>res;
28   if(n == 1){
29     if(sign(coef[1])) res.pb(-coef[0]/coef
           [1]);
30     return res;
31   }
32   vector<double>dcoef(n);
33   for(int i = 0; i < n; ++i) dcoef[i] = coef
         [i+1]*(i+1);
34   vector<double>droot = cal(dcoef, n-1);
35   droot.insert(droot.begin(), -INF);
36   droot.pb(INF);
37   for(int i = 0; i+1 < droot.size(); ++i){
38     double tmp = find(coef, n, droot[i],
         droot[i+1]);
39     if(tmp < INF) res.pb(tmp);
40   }
41   return res;
42 }
43
44 int main () {
45   vector<double>ve;
46   vector<double>ans = cal(ve, n);
47   // 視情況把答案 +eps，避免 -0
48 }
```

8.6 FWT.cpp

```cpp
1  vector<int> F_OR_T(vector<int> f, bool
       inverse){
2    for(int i=0; (2<<i)<=f.size(); ++i)
3      for(int j=0; j<f.size(); j+=2<<i)
4        for(int k=0; k<(1<<i); ++k)
5          f[j+k+(1<<i)] += f[j+k]*(inverse
             ?-1:1);
6    return f;
7  }
8  vector<int> rev(vector<int> A) {
9    for(int i=0; i<A.size(); i+=2)
10     swap(A[i],A[i^(A.size()-1)]);
11   return A;
12 }
13 vector<int> F_AND_T(vector<int> f, bool
       inverse){
14   return rev(F_OR_T(rev(f), inverse));
15 }
16 vector<int> F_XOR_T(vector<int> f, bool
       inverse){
17   for(int i=0; (2<<i)<=f.size(); ++i)
18     for(int j=0; j<f.size(); j+=2<<i)
19       for(int k=0; k<(1<<i); ++k){
20         int u=f[j+k], v=f[j+k+(1<<i)];
21         f[j+k+(1<<i)] = u-v, f[j+k] = u+v;
22       }
23   if(inverse) for(auto &a:f) a/=f.size();
24   return f;
25 }
```

8.7 LinearCongruence.cpp

```cpp
1  pair<LL,LL> LinearCongruence(LL a[],LL b[],
       LL m[],int n) {
2    // a[i]*x = b[i] ( mod m[i] )
3    for(int i=0;i<n;++i) {
4      LL x, y, d = extgcd(a[i],m[i],x,y);
5      if(b[i]%d!=0) return make_pair(-1LL,0LL)
           ;
6      m[i] /= d;
7      b[i] = LLmul(b[i]/d,x,m[i]);
8    }
9    LL lastb = b[0], lastm = m[0];
10   for(int i=1;i<n;++i) {
11     LL x, y, d = extgcd(m[i],lastm,x,y);
12     if((lastb-b[i])%d!=0) return make_pair
           (-1LL,0LL);
13     lastb = LLmul((lastb-b[i])/d,x,(lastm/d)
           )*m[i];
14     lastm = (lastm/d)*m[i];
15     lastb = (lastb+b[i])%lastm;
16   }
17   return make_pair(lastb<0?lastb+lastm:lastb
         ,lastm);
18 }
```

8.8 Lucas.cpp

```cpp
1  int mod_fact(int n,int &e){
2    e=0;
3    if(n==0)return 1;
4    int res=mod_fact(n/P,e);
5    e += n/P;
6    if((n/P)%2==0)return res*fact[n%P]%P;
7    return res*(P-fact[n%P])%P;
```

```cpp
8  }
9  int Cmod(int n,int m){
10   int a1,a2,a3,e1,e2,e3;
11   a1=mod_fact(n,e1);
12   a2=mod_fact(m,e2);
13   a3=mod_fact(n-m,e3);
14   if(e1>e2+e3)return 0;
15   return a1*inv(a2*a3%P,P)%P;
16 }
```

8.9 Matrix.cpp

```cpp
1  template<typename T>
2  struct Matrix{
3    using rt = std::vector<T>;
4    using mt = std::vector<rt>;
5    using matrix = Matrix<T>;
6    int r,c;
7    mt m;
8    Matrix(int r,int c):r(r),c(c),m(r,rt(c)){}
9    rt& operator[](int i){return m[i];}
10   matrix operator+(const matrix &a){
11     matrix rev(r,c);
12     for(int i=0;i<r;++i)
13       for(int j=0;j<c;++j)
14         rev[i][j]=m[i][j]+a.m[i][j];
15     return rev;
16   }
17   matrix operator-(const matrix &a){
18     matrix rev(r,c);
19     for(int i=0;i<r;++i)
20       for(int j=0;j<c;++j)
21         rev[i][j]=m[i][j]-a.m[i][j];
22     return rev;
23   }
24   matrix operator*(const matrix &a){
25     matrix rev(r,a.c);
26     matrix tmp(a.c,a.r);
27     for(int i=0;i<a.r;++i)
28       for(int j=0;j<a.c;++j)
29         tmp[j][i]=a.m[i][j];
30     for(int i=0;i<r;++i)
31       for(int j=0;j<a.c;++j)
32         for(int k=0;k<c;++k)
33           rev.m[i][j]+=m[i][k]*tmp[j][k];
34     return rev;
35   }
36   bool inverse(){
37     Matrix t(r,r+c);
38     for(int y=0;y<r;y++){
39       t.m[y][c+y] = 1;
40       for(int x=0;x<c;++x)
41         t.m[y][x]=m[y][x];
42     }
43     if( !t.gas() )
44       return false;
45     for(int y=0;y<r;y++)
46       for(int x=0;x<c;++x)
47         m[y][x]=t.m[y][c+x]/t.m[y][y];
48     return true;
49   }
50   T gas(){
51     vector<T> lazy(r,1);
52     bool sign=false;
53     for(int i=0;i<r;++i){
54       if( m[i][i]==0 ){
55         int j=i+1;
56         while(j<r&&!m[j][i])j++;
57         if(j==r)continue;
58         m[i].swap(m[j]);
59         sign=!sign;
60       }
61       for(int j=0;j<r;++j){
62         if(i==j)continue;
63         lazy[j]=lazy[j]*m[i][i];
64         T mx=m[j][i];
65         for(int k=0;k<c;++k)
66           m[j][k]=m[j][k]*m[i][i]-m[i][k]*mx
               ;
67       }
68     }
69     T det=sign?-1:1;
70     for(int i=0;i<r;++i)
71       det = det*m[i][i];
72     det = det/lazy[i];
73     for(auto &j:m[i])j/=lazy[i];
74   }
75   return det;
76 }
77 };
```

8.10 MillerRobin.cpp

```cpp
1  LL LLmul(LL a, LL b, const LL &mod) {
2    LL ans=0;
3    while(b) {
4      if(b&1) {
5        ans+=a;
6        if(ans>=mod) ans-=mod;
7      }
8      a<<=1, b>>=1;
9      if(a>=mod) a-=mod;
10   }
11   return ans;
12 }
13 LL mod_mul(LL a,LL b,LL m){
14   a%=m,b%=m;/* fast for m < 2^58 */
15   LL y=(LL)((double)a*b/m+0.5);
16   LL r=(a*b-y*m)%m;
17   return r<0?r+m:r;
18 }
19 template<typename T>
20 T pow(T a,T b,T mod){//a^b%mod
21   T ans=1;
22   for(;b;a=mod_mul(a,a,mod),b>>=1)
23     if(b&1)ans=mod_mul(ans,a,mod);
24   return ans;
25 }
26 int sprp[3]={2,7,61};//int範圍可解
27 int llsprp
       [7]={2,325,9375,28178,450775,9780504,
28 1795265022};//至少unsigned long long範圍
29 template<typename T>
30 bool isprime(T n,int *sprp,int num){
31   if(n==2)return 1;
```

```
32    if(n<2||n%2==0)return 0;
33    int t=0;
34    T u=n-1;
35    for(;u%2==0;++t)u>>=1;
36    for(int i=0;i<num;++i){
37        T a=sprp[i]%n;
38        if(a==0||a==1||a==n-1)continue;
39        T x=pow(a,u,n);
40        if(x==1||x==n-1)continue;
41        for(int j=0;j<t;++j){
42            x=mod_mul(x,x,n);
43            if(x==1)return 0;
44            if(x==n-1)break;
45        }
46        if(x==n-1)continue;
47        return 0;
48    }
49    return 1;
50 }
```

8.11   NTT.cpp

```
1  2615053605667*(2^18)+1,3
2  15*(2^27)+1,31
3  479*(2^21)+1,3
4  7*17*(2^23)+1,3
5  3*3*211*(2^19)+1,5
6  25*(2^22)+1,3
7  template<typename T,typename VT=vector<T> >
8  struct NTT{
9      const T P,G;
10     NTT(T p=(1<<23)*7*17+1,T g=3):P(p),G(g){}
11     unsigned bit_reverse(unsigned a,int len){
12         //look FFT.cpp
13     }
14     T pow_mod(T n,T k,T m){
15         T ans=1;
16         for(n=(n>=m?n%m:n);k;k>>=1){
17             if(k&1)ans=ans*n%m;
18             n=n*n%m;
19         }
20         return ans;
21     }
22     void ntt(bool is_inv,VT &in,VT &out,int N)
       {
23         int bitlen=__lg(N);
24         for(int i=0;i<N;++i)out[bit_reverse(i,
             bitlen)]=in[i];
25         for(int step=2,id=1;step<=N;step<<=1,++
             id){
26             T wn=pow_mod(G,(P-1)>>id,P),wi=1,u,t;
27             const int mh=step>>1;
28             for(int i=0;i<mh;++i){
29                 for(int j=i;j<N;j+=step){
30                     u=out[j],t=wi*out[j+mh]%P;
31                     out[j]=u+t;
32                     out[j+mh]=u-t;
33                     if(out[j]>=P)out[j]-=P;
34                     if(out[j+mh]<0)out[j+mh]+=P;
35                 }
36                 wi=wi*wn%P;
37             }
38         }
```

```
39     if(is_inv){
40         for(int i=1;i<N/2;++i)swap(out[i],out[
             N-i]);
41         T invn=pow_mod(N,P-2,P);
42         for(int i=0;i<N;++i)out[i]=out[i]*invn
             %P;
43     }
44     }
45 };
```

8.12   Simpson.cpp

```
1  double simpson(double a,double b){
2      double c=a+(b-a)/2;
3      return (F(a)+4*F(c)+F(b))*(b-a)/6;
4  }
5  double asr(double a,double b,double eps,
       double A){
6      double c=a+(b-a)/2;
7      double L=simpson(a,c),R=simpson(c,b);
8      if( abs(L+R-A)<15*eps )
9          return L+R+(L+R-A)/15.0;
10     return asr(a,c,eps/2,L)+asr(c,b,eps/2,R);
11 }
12 double asr(double a,double b,double eps){
13     return asr(a,b,eps,simpson(a,b));
14 }
```

8.13   外星模運算.cpp

```
1  //a[0]^(a[1]^a[2]^...)
2  #define maxn 1000000
3  int euler[maxn+5];
4  bool is_prime[maxn+5];
5  void init_euler(){
6      is_prime[1]=1;//一不是質數
7      for(int i=1;i<=maxn;i++)euler[i]=i;
8      for(int i=2;i<=maxn;i++){
9          if(!is_prime[i]){//是質數
10             euler[i]--;
11             for(int j=i<<1;j<=maxn;j+=i){
12                 is_prime[j]=1;
13                 euler[j]=euler[j]/i*(i-1);
14             }
15         }
16     }
17 }
18 LL pow(LL a,LL b,LL mod){//a^b%mod
19     LL ans=1;
20     for(;b;a=a*a%mod,b>>=1)
21         if(b&1)ans=ans*a%mod;
22     return ans;
23 }
24 bool isless(LL *a,int n,int k){
25     if(*a==1)return k>1;
26     if(--n==0)return *a<k;
27     int next=0;
28     for(LL b=1;b<k;++next)
29         b*=*a;
```

```
30     return isless(a+1,n,next);
31 }
32 LL high_pow(LL *a,int n,LL mod){
33     if(*a==1||--n==0)return *a%mod;
34     int k=0,r=euler[mod];
35     for(LL tma=1;tma!=pow(*a,k+r,mod);++k)
36         tma=tma*(*a)%mod;
37     if(isless(a+1,n,k))return pow(*a,high_pow(
         a+1,n,k),mod);
38     int tmd=high_pow(a+1,n,r), t=(tmd-k+r)%r;
39     return pow(*a,k+t,mod);
40 }
41 LL a[1000005];
42 int t,mod;
43 int main(){
44     init_euler();
45     scanf("%d",&t);
46     #define n 4
47     while(t--){
48         for(int i=0;i<n;++i)scanf("%lld",&a[i]);
49         scanf("%d",&mod);
50         printf("%lld\n",high_pow(a,n,mod));
51     }
52     return 0;
53 }
```

8.14   質因數分解.cpp

```
1  LL func(const LL n,const LL mod,const int c)
       {
2      return (LLmul(n,n,mod)+c+mod)%mod;
3  }
4
5  LL pollorrho(const LL n, const int c) {//循
       環節長度
6      LL a=1, b=1;
7      a=func(a,n,c)%n;
8      b=func(b,n,c)%n; b=func(b,n,c)%n;
9      while(gcd(abs(a-b),n)==1) {
10         a=func(a,n,c)%n;
11         b=func(b,n,c)%n; b=func(b,n,c)%n;
12     }
13     return gcd(abs(a-b),n);
14 }
15
16 void prefactor(LL &n, vector<LL> &v) {
17     for(int i=0;i<12;++i) {
18         while(n%prime[i]==0) {
19             v.push_back(prime[i]);
20             n/=prime[i];
21         }
22     }
23 }
24
25 void smallfactor(LL n, vector<LL> &v) {
26     if(n<MAXPRIME) {
27         while(isp[(int)n]) {
28             v.push_back(isp[(int)n]);
29             n/=isp[(int)n];
30         }
31         v.push_back(n);
32     } else {
```

```
33         for(int i=0;i<primecnt&&prime[i]*prime[i
             ]<=n;++i) {
34             while(n%prime[i]==0) {
35                 v.push_back(prime[i]);
36                 n/=prime[i];
37             }
38         }
39         if(n!=1) v.push_back(n);
40     }
41 }
42
43 void comfactor(const LL &n, vector<LL> &v) {
44     if(n<1e9) {
45         smallfactor(n,v);
46         return;
47     }
48     if(Isprime(n)) {
49         v.push_back(n);
50         return;
51     }
52     LL d;
53     for(int c=3;;++c) {
54         d = pollorrho(n,c);
55         if(d!=n) break;
56     }
57     comfactor(d,v);
58     comfactor(n/d,v);
59 }
60
61 void Factor(const LL &x, vector<LL> &v) {
62     LL n = x;
63     if(n==1) { puts("Factor 1"); return; }
64     prefactor(n,v);
65     if(n==1) return;
66     comfactor(n,v);
67     sort(v.begin(),v.end());
68 }
69
70 void AllFactor(const LL &n,vector<LL> &v) {
71     vector<LL> tmp;
72     Factor(n,tmp);
73     v.clear();
74     v.push_back(1);
75     int len;
76     LL now=1;
77     for(int i=0;i<tmp.size();++i) {
78         if(i==0 || tmp[i]!=tmp[i-1]) {
79             len = v.size();
80             now = 1;
81         }
82         now*=tmp[i];
83         for(int j=0;j<len;++j)
84             v.push_back(v[j]*now);
85     }
86 }
```

9   other

9.1   WhatDay.cpp

```
1  int whatday(int y,int m,int d){
```

```
2    if(m<=2)m+=12,--y;
3    if(y<1752||y==1752&&m<9||y==1752&&m==9&&d
       <3)
4      return (d+2*m+3*(m+1)/5+y+y/4+5)%7;
5    return (d+2*m+3*(m+1)/5+y+y/4-y/100+y/400)
       %7;
6  }
```

9.2 上下最大正方形.cpp

```
1  void solve(int n,int a[],int b[]){// 1-base
2    int ans=0;
3    deque<int>da,db;
4    for(int l=1,r=1;r<=n;++r){
5      while(da.size()&&a[da.back()]>=a[r]){
6        da.pop_back();
7      }
8      da.push_back(r);
9      while(db.size()&&b[db.back()]>=b[r]){
10       db.pop_back();
11     }
12     db.push_back(r);
13     for(int d=a[da.front()]+b[db.front()];r-
         l+1>d;++l){
14       if(da.front()==l)da.pop_front();
15       if(db.front()==l)db.pop_front();
16       if(da.size()&&db.size()){
17         d=a[da.front()]+b[db.front()];
18       }
19     }
20     ans=max(ans,r-l+1);
21   }
22   printf("%d\n",ans);
23 }
```

9.3 最大矩形.cpp

```
1  LL max_rectangle(vector<int> s){
2    stack<pair<int,int > > st;
3    st.push(make_pair(-1,0));
4    s.push_back(0);
5    LL ans=0;
6    for(size_t i=0;i<s.size();++i){
7      int h=s[i];
8      pair<int,int > now=make_pair(h,i);
9      while(h<st.top().first){
10       now=st.top();
11       st.pop();
12       ans=max(ans,(LL)(i-now.second)*now.
           first);
13     }
14     if(h>st.top().first){
15       st.push(make_pair(h,now.second));
16     }
17   }
18   return ans;
19 }
```

10 String

10.1 AC 自動機.cpp

```
1  template<char L='a',char R='z'>
2  class ac_automaton{
3    struct joe{
4      int next[R-L+1],fail,efl,ed,cnt_dp,vis;
5      joe():ed(0),cnt_dp(0),vis(0){
6        for(int i=0;i<=R-L;++i)next[i]=0;
7      }
8    };
9  public:
10   std::vector<joe> S;
11   std::vector<int> q;
12   int qs,qe,vt;
13   ac_automaton():S(1),qs(0),qe(0),vt(0){}
14   void clear(){
15     q.clear();
16     S.resize(1);
17     for(int i=0;i<=R-L;++i)S[0].next[i]=0;
18     S[0].cnt_dp=S[0].vis=qs=qe=vt=0;
19   }
20   void insert(const char *s){
21     int o=0;
22     for(int i=0,id;s[i];++i){
23       id=s[i]-L;
24       if(!S[o].next[id]){
25         S.push_back(joe());
26         S[o].next[id]=S.size()-1;
27       }
28       o=S[o].next[id];
29     }
30     ++S[o].ed;
31   }
32   void build_fail(){
33     S[0].fail=S[0].efl=-1;
34     q.clear();
35     q.push_back(0);
36     ++qe;
37     while(qs!=qe){
38       int pa=q[qs++],id,t;
39       for(int i=0;i<=R-L;++i){
40         t=S[pa].next[i];
41         if(!t)continue;
42         id=S[pa].fail;
43         while(~id&&!S[id].next[i])id=S[id].
             fail;
44         S[t].fail=~id?S[id].next[i]:0;
45         S[t].efl=S[S[t].fail].ed?S[t].fail:S
             [S[t].fail].efl;
46         q.push_back(t);
47         ++qe;
48       }
49     }
50   }
```
/*DP出每個前綴在字串s出現的次數並傳回所有
字串被s匹配成功的次數O(N+M)*/
```
52   int match_0(const char *s){
53     int ans=0,id,p=0,i;
54     for(i=0;s[i];++i){
55       id=s[i]-L;
56       while(!S[p].next[id]&&p)p=S[p].fail;
57       if(!S[p].next[id])continue;
58       p=S[p].next[id];
59       ++S[p].cnt_dp;/*匹配成功則它所有後綴都
           可以被匹配(DP計算)*/
60     }
61     for(i=qe-1;i>=0;--i){
62       ans+=S[q[i]].cnt_dp*S[q[i]].ed;
63       if(~S[q[i]].fail)S[S[q[i]].fail].
           cnt_dp+=S[q[i]].cnt_dp;
64     }
65     return ans;
66   }
```
/*多串匹配走efl邊並傳回所有字串被s匹配成功
的次數O(N*M^1.5)*/
```
68   int match_1(const char *s)const{
69     int ans=0,id,p=0,t;
70     for(int i=0;s[i];++i){
71       id=s[i]-L;
72       while(!S[p].next[id]&&p)p=S[p].fail;
73       if(!S[p].next[id])continue;
74       p=S[p].next[id];
75       if(S[p].ed)ans+=S[p].ed;
76       for(t=S[p].efl;~t;t=S[t].efl){
77         ans+=S[t].ed;/*因為都走efl邊所以保證
             匹配成功*/
78       }
79     }
80     return ans;
81   }
```
/*枚舉(s的子字串nA)的所有相異字串各恰一次
並傳回次數O(N*M^(1/3))*/
```
83   int match_2(const char *s){
84     int ans=0,id,p=0,t;
85     ++vt;
```
    /*把戳記vt+=1，只要vt沒溢位，所有S[p].
      vis==vt就會變成false
    這種利用vt的方法可以O(1)歸零vis陣列*/
```
88     for(int i=0;s[i];++i){
89       id=s[i]-L;
90       while(!S[p].next[id]&&p)p=S[p].fail;
91       if(!S[p].next[id])continue;
92       p=S[p].next[id];
93       if(S[p].ed&&S[p].vis!=vt){
94         S[p].vis=vt;
95         ans+=S[p].ed;
96       }
97       for(t=S[p].efl;~t&&S[t].vis!=vt;t=S[t
           ].efl){
98         S[t].vis=vt;
99         ans+=S[t].ed;/*因為都走efl邊所以保證
             匹配成功*/
100      }
101    }
102    return ans;
103  }
```
/*把AC自動機變成真的自動機*/
```
105  void evolution(){
106    for(qs=1;qs!=qe;){
107      int p=q[qs++];
108      for(int i=0;i<=R-L;++i)
109        if(S[p].next[i]==0)S[p].next[i]=S[S[
             p].fail].next[i];
110    }
111  }
112 };
```

10.2 hash.cpp

```
1  #define MAXN 1000000
2  #define mod 1073676287
```
/*mod 必須要是質數*/
```
4  typedef long long T;
5  char s[MAXN+5];
6  T h[MAXN+5];/*hash陣列*/
7  T h_base[MAXN+5];/*h_base[n]=(prime^n)%mod*/
8  void hash_init(int len,T prime){
9    h_base[0]=1;
10   for(int i=1;i<=len;++i){
11     h[i]=(h[i-1]*prime+s[i-1])%mod;
12     h_base[i]=(h_base[i-1]*prime)%mod;
13   }
14 }
15 T get_hash(int l,int r){/*閉區間寫法，設編號
     為0 ~ len-1*/
16   return (h[r+1]-(h[l]*h_base[r-l+1])%mod+
       mod)%mod;
17 }
```

10.3 KMP.cpp

```
```
/*產生fail function*/
```
2  void kmp_fail(char *s,int len,int *fail){
3    int id=-1;
4    fail[0]=-1;
5    for(int i=1;i<len;++i){
6      while(~id&&s[id+1]!=s[i])id=fail[id];
7      if(s[id+1]==s[i])++id;
8      fail[i]=id;
9    }
10 }
```
/*以字串B匹配字串A，傳回匹配成功的數量(用B的
fail)*/
```
12 int kmp_match(char *A,int lenA,char *B,int
     lenB,int *fail){
13   int id=-1,ans=0;
14   for(int i=0;i<lenA;++i){
15     while(~id&&B[id+1]!=A[i])id=fail[id];
16     if(B[id+1]==A[i])++id;
17     if(id==lenB-1){/*匹配成功*/
18       ++ans, id=fail[id];
19     }
20   }
21   return ans;
22 }
```

10.4 manacher.cpp

```
1  //原字串: asdsasdsa
2  //先把字串變成這樣: @#a#s#d#s#a#s#d#s#a#
3  void manacher(char *s,int len,int *z){
4    int l=0,r=0;
5    for(int i=1;i<len;++i){
6      z[i]=r>i?min(z[2*l-i],r-i):1;
7      while(s[i+z[i]]==s[i-z[i]])++z[i];
8      if(z[i]+i>r)r=z[i]+i,l=i;
9    }//ans = max(z)-1
10 }
```

10.5 minimal_string_rotation.cpp

```
1  int min_string_rotation(const string &s){
2    int n=s.size(),i=0,j=1,k=0;
3    while(i<n&&j<n&&k<n){
4      int t=s[(i+k)%n]-s[(j+k)%n];
5      ++k;
6      if(t){
7        if(t>0)i+=k;
8        else j+=k;
9        if(i==j)++j;
10       k=0;
11     }
12   }
13   return min(i,j);//最小循環表示法起始位置
14 }
```

10.6 reverseBWT.cpp

```
1  const int MAXN = 305, MAXC = 'Z';
2  int ranks[MAXN], tots[MAXC], first[MAXC];
3  void rankBWT(const string &bw){
4    memset(ranks,0,sizeof(int)*bw.size());
5    memset(tots,0,sizeof(tots));
6    for(size_t i=0;i<bw.size();++i)
7      ranks[i] = tots[int(bw[i])]++;
8  }
9  void firstCol(){
10   memset(first,0,sizeof(first));
11   int totc = 0;
12   for(int c='A';c<='Z';++c){
13     if(!tots[c]) continue;
14     first[c] = totc;
15     totc += tots[c];
16   }
17 }
18 string reverseBwt(string bw,int begin){
19   rankBWT(bw), firstCol();
20   int i = begin; //原字串最後一個元素的位置
21   string res;
22   do{
23     char c = bw[i];
24     res = c + res;
25     i = first[int(c)] + ranks[i];
26   }while( i != begin );
27   return res;
28 }
```

10.7 suffix_array_lcp.cpp

```
1  #define radix_sort(x,y){\
2    for(i=0;i<A;++i)c[i]=0;\
3    for(i=0;i<n;++i)c[x[y[i]]]++;\
4    for(i=1;i<A;++i)c[i]+=c[i-1];\
5    for(i=n-1;~i;--i)sa[--c[x[y[i]]]]=y[i];\
6  }
7  #define AC(r,a,b)\
8    r[a]!=r[b]||a+k>=n||r[a+k]!=r[b+k]
9  void suffix_array(const char *s,int n,int *
        sa,int *rank,int *tmp,int *c){
10   int A='z'+1,i,k,id=0;
11   for(i=0;i<n;++i)rank[tmp[i]=i]=s[i];
12   radix_sort(rank,tmp);
13   for(k=1;id<n-1;k<<=1){
14     for(id=0,i=n-k;i<n;++i)tmp[id++]=i;
15     for(i=0;i<n;++i)
16       if(sa[i]>=k)tmp[id++]=sa[i]-k;
17     radix_sort(rank,tmp);
18     swap(rank,tmp);
19     for(rank[sa[0]]=id=0,i=1;i<n;++i)
20       rank[sa[i]]=id+=AC(tmp,sa[i-1],sa[i]);
21     A=id+1;
22   }
23 }
24 //h:高度數組 sa:後綴數組 rank:排名
25 void suffix_array_lcp(const char *s,int len,
        int *h,int *sa,int *rank){
26   for(int i=0;i<len;++i)rank[sa[i]]=i;
27   for(int i=0,k=0;i<len;++i){
28     if(rank[i]==0)continue;
29     if(k)--k;
30     while(s[i+k]==s[sa[rank[i]-1]+k])++k;
31     h[rank[i]]=k;
32   }
33   h[0]=0;// h[k]=lcp(sa[k],sa[k-1]);
34 }
```

10.8 Z.cpp

```
1  void z_alg(char *s,int len,int *z){
2    int l=0,r=0;
3    z[0]=len;
4    for(int i=1;i<len;++i){
5      z[i]=i>r?0:(i-l+z[i-l]<z[l]?z[i-l]:r-i
          +1);
6      while(i+z[i]<len&&s[i+z[i]]==s[z[i]])++z
          [i];
7      if(i+z[i]-1>r)r=i+z[i]-1,l=i;
8    }
9  }
```

11 Tarjan

11.1 dominator_tree.cpp

```
1  struct dominator_tree{
2    static const int MAXN=5005;
3    int n;// 1-base
4    vector<int> suc[MAXN],pre[MAXN];
5    int fa[MAXN],dfn[MAXN],id[MAXN],Time;
6    int semi[MAXN],idom[MAXN];
7    int anc[MAXN],best[MAXN];//disjoint set
8    vector<int> dom[MAXN];//dominator_tree
9    void init(int _n){
10     n=_n;
11     for(int i=1;i<=n;++i)suc[i].clear(),pre[
          i].clear();
12   }
13   void add_edge(int u,int v){
14     suc[u].push_back(v);
15     pre[v].push_back(u);
16   }
17   void dfs(int u){
18     dfn[u]=++Time,id[Time]=u;
19     for(auto v:suc[u]){
20       if(dfn[v])continue;
21       dfs(v),fa[dfn[v]]=dfn[u];
22     }
23   }
24   int find(int x){
25     if(x==anc[x])return x;
26     int y=find(anc[x]);
27     if(semi[best[x]]>semi[best[anc[x]]])best
          [x]=best[anc[x]];
28     return anc[x]=y;
29   }
30   void tarjan(int r){
31     Time=0;
32     for(int t=1;t<=n;++t){
33       dfn[t]=idom[t]=0;//u=r或是u無法到達r時
              idom[id[u]]=0
34       dom[t].clear();
35       anc[t]=best[t]=semi[t]=t;
36     }
37     dfs(r);
38     for(int y=Time;y>=2;--y){
39       int x=fa[y],idy=id[y];
40       for(auto z:pre[idy]){
41         if(!(z=dfn[z]))continue;
42         find(z);
43         semi[y]=min(semi[y],semi[best[z]]);
44       }
45       dom[semi[y]].push_back(y);
46       anc[y]=x;
47       for(auto z:dom[x]){
48         find(z);
49         idom[z]=semi[best[z]]<x?best[z]:x;
50       }
51       dom[x].clear();
52     }
53     for(int u=2;u<=Time;++u){
54       if(idom[u]!=semi[u])idom[u]=idom[idom[
              u]];
55       dom[id[idom[u]]].push_back(id[u]);
56     }
57   }
58 }dom;
```

11.2 tnfshb017_2_sat.cpp

```
1  #include<bits/stdc++.h>
2  using namespace std;
3  #define MAXN 8001
4  #define MAXN2 MAXN*4
5  #define n(X) ((X)+2*N)
6  vector<int> v[MAXN2], rv[MAXN2], vis_t;
7  int N,M;
8  void addedge(int s,int e){
9    v[s].push_back(e);
10   rv[e].push_back(s);
11 }
12 int scc[MAXN2];
13 bool vis[MAXN2]={false};
14 void dfs(vector<int> *uv,int n,int k=-1){
15   vis[n]=true;
16   for(int i=0;i<uv[n].size();++i)
17     if(!vis[uv[n][i]])
18       dfs(uv,uv[n][i],k);
19   if(uv==v)vis_t.push_back(n);
20   scc[n]=k;
21 }
22 void solve(){
23   for(int i=1;i<=N;++i){
24     if(!vis[i])dfs(v,i);
25     if(!vis[n(i)])dfs(v,n(i));
26   }
27   memset(vis,0,sizeof(vis));
28   int c=0;
29   for(int i=vis_t.size()-1;i>=0;--i)
30     if(!vis[vis_t[i]])
31       dfs(rv,vis_t[i],c++);
32 }
33 int main(){
34   int a,b;
35   scanf("%d%d",&N,&M);
36   for(int i=1;i<=N;++i){
37     // (A or B)&(!A & !B) A^B
38     a=i*2-1;
39     b=i*2;
40     addedge(n(a),b);
41     addedge(n(b),a);
42     addedge(a,n(b));
43     addedge(b,n(a));
44   }
45   while(M--){
46     scanf("%d%d",&a,&b);
47     a = a>0?a*2-1:-a*2;
48     b = b>0?b*2-1:-b*2;
49     // A or B
50     addedge(n(a),b);
51     addedge(n(b),a);
52   }
53   solve();
54   bool check=true;
55   for(int i=1;i<=2*N;++i)
56     if(scc[i]==scc[n(i)])
57       check=false;
58   if(check){
59     printf("%d\n",N);
60     for(int i=1;i<=2*N;i+=2){
61       if(scc[i]>scc[i+2*N]) putchar('+');
62       else putchar('-');
63     }
```

```cpp
64    puts("");
65  }else puts("0");
66  return 0;
67 }
```

11.3 橋連通分量.cpp

```cpp
1  #define N 1005
2  struct edge{
3    int u,v;
4    bool is_bridge;
5    edge(int u=0,int v=0):u(u),v(v),is_bridge
        (0){}
6  };
7  vector<edge> E;
8  vector<int> G[N];// 1-base
9  int low[N],vis[N],Time;
10 int bcc_id[N],bridge_cnt,bcc_cnt;// 1-base
11 int st[N],top;//BCC用
12 inline void add_edge(int u,int v){
13   G[u].push_back(E.size());
14   E.push_back(edge(u,v));
15   G[v].push_back(E.size());
16   E.push_back(edge(v,u));
17 }
18 void dfs(int u,int re=-1){//u當前點，re為u連
        接前一個點的邊
19   int v;
20   low[u]=vis[u]=++Time;
21   st[top++]=u;
22   for(size_t i=0;i<G[u].size();++i){
23     int e=G[u][i];v=E[e].v;
24     if(!vis[v]){
25       dfs(v,e^1);//e^1反向邊
26       low[u]=min(low[u],low[v]);
27       if(vis[u]<low[v]){
28         E[e].is_bridge=E[e^1].is_bridge=1;
29         ++bridge_cnt;
30       }
31     }else if(vis[v]<vis[u]&&e!=re)
32       low[u]=min(low[u],vis[v]);
33   }
34   if(vis[u]==low[u]){//處理BCC
35     ++bcc_cnt;// 1-base
36     do bcc_id[v=st[--top]]=bcc_cnt;//每個點
            所在的BCC
37     while(v!=u);
38   }
39 }
40 inline void bcc_init(int n){
41   Time=bcc_cnt=bridge_cnt=top=0;
42   E.clear();
43   for(int i=1;i<=n;++i){
44     G[i].clear();
45     vis[i]=bcc_id[i]=0;
46   }
47 }
```

11.4 雙連通分量 & 割點.cpp

```cpp
1  #define N 1005
2  vector<int> G[N];// 1-base
3  vector<int> bcc[N];//存每塊雙連通分量的點
4  int low[N],vis[N],Time;
5  int bcc_id[N],bcc_cnt;// 1-base
6  bool is_cut[N];//是否為割點
7  int st[N],top;
8  void dfs(int u,int pa=-1){//u當前點，pa父親
9    int v,child=0;
10   low[u]=vis[u]=++Time;
11   st[top++]=u;
12   for(size_t i=0;i<G[u].size();++i){
13     if(!vis[v=G[u][i]]){
14       dfs(v,u),++child;
15       low[u]=min(low[u],low[v]);
16       if(vis[u]<=low[v]){
17         is_cut[u]=1;
18         bcc[++bcc_cnt].clear();
19         int t;
20         do{
21           bcc_id[t=st[--top]]=bcc_cnt;
22           bcc[bcc_cnt].push_back(t);
23         }while(t!=v);
24         bcc_id[u]=bcc_cnt;
25         bcc[bcc_cnt].push_back(u);
26       }
27     }else if(vis[v]<vis[u]&&v!=pa)//反向邊
28       low[u]=min(low[u],vis[v]);
29   }
30   if(pa==-1&&child<2)is_cut[u]=0;//u是dfs樹
          的根要特判
31 }
32 inline void bcc_init(int n){
33   Time=bcc_cnt=top=0;
34   for(int i=1;i<=n;++i){
35     G[i].clear();
36     is_cut[i]=vis[i]=bcc_id[i]=0;
37   }
38 }
```

12 Tree_problem

12.1 HeavyLight.cpp

```cpp
1  #include<vector>
2  #define MAXN 100005
3  int siz[MAXN],max_son[MAXN],pa[MAXN],dep[
       MAXN];
4  int link_top[MAXN],link[MAXN],cnt;
5  vector<int> G[MAXN];
6  void find_max_son(int u){
7    siz[u]=1;
8    max_son[u]=-1;
9    for(auto v:G[u]){
10     if(v==pa[u])continue;
11     pa[v]=u;
12     dep[v]=dep[u]+1;
13     find_max_son(v);
14     if(max_son[u]==-1||siz[v]>siz[max_son[u
           ]])max_son[u]=v;
15     siz[u]+=siz[v];
16   }
17 }
18 void build_link(int u,int top){
19   link[u]=++cnt;
20   link_top[u]=top;
21   if(max_son[u]==-1)return;
22   build_link(max_son[u],top);
23   for(auto v:G[u]){
24     if(v==max_son[u]||v==pa[u])continue;
25     build_link(v,v);
26   }
27 }
28 int find_lca(int a,int b){
29   //求LCA，可以在過程中對區間進行處理
30   int ta=link_top[a],tb=link_top[b];
31   while(ta!=tb){
32     if(dep[ta]<dep[tb]){
33       swap(ta,tb);
34       swap(a,b);
35     }
36     //這裡可以對a所在的鏈做區間處理
37     //區間為(link[ta],link[a])
38     ta=link_top[a=pa[ta]];
39   }
40   //最後a,b會在同一條鏈，若a!=b還要在進行一
          次區間處理
41   return dep[a]<dep[b]?a:b;
42 }
```

12.2 LCA.cpp

```cpp
1  #define MAXN 100000
2  #define MAX_LOG 17
3  int pa[MAX_LOG+1][MAXN+5];
4  int dep[MAXN+5];
5  vector<int> G[MAXN+5];
6  void dfs(int x,int p){//dfs(1,-1);
7    pa[0][x]=p;
8    for(int i=0;i+1<MAX_LOG;++i)pa[i+1][x]=pa[
         i][pa[i][x]];
9    for(auto &i:G[x]){
10     if(i==p)continue;
11     dep[i]=dep[x]+1;
12     dfs(i,x);
13   }
14 }
15 inline int jump(int x,int d){
16   for(int i=0;i<d;++i)if((x>>i)&1)x=pa[k][x];
17   return x;
18 }
19 inline int find_lca(int a,int b){
20   if(dep[a]>dep[b])swap(a,b);
21   b=jump(b,dep[b]-dep[a]);
22   if(a==b)return a;
23   for(int i=MAX_LOG;i>=0;--i){
24     if(pa[i][a]!=pa[i][b]){
25       a=pa[i][a];
26       b=pa[i][b];
27     }
28   }
29   return pa[0][a];
```

12.3 link_cut_tree.cpp

```cpp
1  struct splay_tree{
2    int ch[2],pa;//子節點跟父母
3    bool rev;//反轉的懶惰標記
4    splay_tree():pa(0),rev(0){ch[0]=ch[1]=0;}
5  };
6  vector<splay_tree> nd;
7  //有的時候用vector會TLE，要注意
8  //這邊以node[0]作為null節點
9  bool isroot(int x){//判斷是否為這棵splay
       tree的根
10   return nd[nd[x].pa].ch[0]!=x&&nd[nd[x].pa
         ].ch[1]!=x;
11 }
12 void down(int x){//懶惰標記下推
13   if(nd[x].rev){
14     if(nd[x].ch[0])nd[nd[x].ch[0]].rev^=1;
15     if(nd[x].ch[1])nd[nd[x].ch[1]].rev^=1;
16     swap(nd[x].ch[0],nd[x].ch[1]);
17     nd[x].rev=0;
18   }
19 }
20 void push_down(int x){//所有祖先懶惰標記下推
21   if(!isroot(x))push_down(nd[x].pa);
22   down(x);
23 }
24 void up(int x){}//將子節點的資訊向上更新
25 void rotate(int x){//旋轉，會自行判斷轉的方
       向
26   int y=nd[x].pa,z=nd[y].pa,d=(nd[y].ch[1]==
         x);
27   nd[x].pa=z;
28   if(!isroot(y))nd[z].ch[nd[z].ch[1]==y]=x;
29   nd[y].ch[d]=nd[x].ch[d^1];
30   nd[nd[y].ch[d]].pa=y;
31   nd[y].pa=x,nd[x].ch[d^1]=y;
32   up(y),up(x);
33 }
34 void splay(int x){//將x伸展到splay tree的根
35   push_down(x);
36   while(!isroot(x)){
37     int y=nd[x].pa;
38     if(!isroot(y)){
39       int z=nd[y].pa;
40       if((nd[z].ch[0]==y)^(nd[y].ch[0]==x))
           rotate(y);
41       else rotate(x);
42     }
43     rotate(x);
44   }
45 }
46 int access(int x){
47   int last=0;
48   while(x){
49     splay(x);
50     nd[x].ch[1]=last;
51     up(x);
52     last=x;
```

```cpp
53      x=nd[x].pa;
54    }
55    return last;//access後splay tree的根
56 }
57 void access(int x,bool is=0){//is=0就是一般
         的access
58    int last=0;
59    while(x){
60      splay(x);
61      if(is&&!nd[x].pa){
62        //printf("%d\n",max(nd[last].ma,nd[nd[
             x].ch[1]].ma));
63      }
64      nd[x].ch[1]=last;
65      up(x);
66      last=x;
67      x=nd[x].pa;
68    }
69 }
70 void query_edge(int u,int v){
71    access(u);
72    access(v,1);
73 }
74 void make_root(int x){
75    access(x),splay(x);
76    nd[x].rev^=1;
77 }
78 void make_root(int x){
79    nd[access(x)].rev^=1;
80    splay(x);
81 }
82 void cut(int x,int y){
83    make_root(x);
84    access(y);
85    splay(y);
86    nd[y].ch[0]=0;
87    nd[x].pa=0;
88 }
89 void cut_parents(int x){
90    access(x);
91    splay(x);
92    nd[nd[x].ch[0]].pa=0;
93    nd[x].ch[0]=0;
94 }
95 void link(int x,int y){
96    make_root(x);
97    nd[x].pa=y;
98 }
99 int find_root(int x){
100   x=access(x);
101   while(nd[x].ch[0])x=nd[x].ch[0];
102   splay(x);
103   return x;
104 }
105 int query(int u,int v){
106 //傳回uv路徑splay tree的根結點
107 //這種寫法無法求LCA
108   make_root(u);
109   return access(v);
110 }
111 int query_lca(int u,int v){
112 //假設求鏈上點權的總和，sum是子樹的權重和，
         data是節點的權重
113   access(u);
```

```cpp
114   int lca=access(v);
115   splay(u);
116   if(u==lca){
117     //return nd[lca].data+nd[nd[lca].ch[1]].
             sum
118   }else{
119     //return nd[lca].data+nd[nd[lca].ch[1]].
             sum+nd[u].sum
120   }
121 }
122 struct EDGE{
123   int a,b,w;
124 }e[10005];
125 int n;
126 vector<pair<int,int>> G[10005];
127 //first表示子節點，second表示邊的編號
128 int pa[10005],edge_node[10005];
129 //pa是父母節點，暫存用的，edge_node是每個編
         被存在哪個點裡面的陣列
130 void bfs(int root){
131 //在建構的時候把每個點都設成一個splay tree
132   queue<int > q;
133   for(int i=1;i<=n;++i)pa[i]=0;
134   q.push(root);
135   while(q.size()){
136     int u=q.front();
137     q.pop();
138     for(auto P:G[u]){
139       int v=P.first;
140       if(v!=pa[u]){
141         pa[v]=u;
142         nd[v].pa=u;
143         nd[v].data=e[P.second].w;
144         edge_node[P.second]=v;
145         up(v);
146         q.push(v);
147       }
148     }
149   }
150 }
151 void change(int x,int b){
152   splay(x);
153   //nd[x].data=b;
154   up(x);
155 }
```

12.4   POJ_tree.cpp

```cpp
1  #include<bits/stdc++.h>
2  using namespace std;
3  #define MAXN 10005
4  int n,k;
5  vector<pair<int,int> >g[MAXN];
6  int size[MAXN];
7  bool vis[MAXN];
8  inline void init(){
9    for(int i=0;i<=n;++i){
10     g[i].clear();
11     vis[i]=0;
12   }
13 }
```

```cpp
14 void get_dis(vector<int> &dis,int u,int pa,
       int d){
15   dis.push_back(d);
16   for(size_t i=0;i<g[u].size();++i){
17     int v=g[u][i].first,w=g[u][i].second;
18     if(v!=pa&&!vis[v])get_dis(dis,v,u,d+w);
19   }
20 }
21 vector<int> dis;//這東西如果放在函數裡會TLE
22 int cal(int u,int d){
23   dis.clear();
24   get_dis(dis,u,-1,d);
25   sort(dis.begin(),dis.end());
26   int l=0,r=dis.size()-1,res=0;
27   while(l<r){
28     while(l<r&&dis[l]+dis[r]>k)--r;
29     res+=r-(l++);
30   }
31   return res;
32 }
33 pair<int,int> tree_centroid(int u,int pa,
       const int sz){
34   size[u]=1;//找樹重心，second是重心
35   pair<int,int> res(INT_MAX,-1);
36   int ma=0;
37   for(size_t i=0;i<g[u].size();++i){
38     int v=g[u][i].first;
39     if(v==pa||vis[v])continue;
40     res=min(res,tree_centroid(v,u,sz));
41     size[u]+=size[v];
42     ma=max(ma,size[v]);
43   }
44   ma=max(ma,sz-size[u]);
45   return min(res,make_pair(ma,u));
46 }
47 int tree_DC(int u,int sz){
48   int center=tree_centroid(u,-1,sz).second;
49   int ans=cal(center,0);
50   vis[center]=1;
51   for(size_t i=0;i<g[center].size();++i){
52     int v=g[center][i].first,w=g[center][i].
           second;
53     if(vis[v])continue;
54     ans-=cal(v,w);
55     ans+=tree_DC(v,size[v]);
56   }
57   return ans;
58 }
59 int main(){
60   while(scanf("%d%d",&n,&k),n||k){
61     init();
62     for(int i=1;i<n;++i){
63       int u,v,w;
64       scanf("%d%d%d",&u,&v,&w);
65       g[u].push_back(make_pair(v,w));
66       g[v].push_back(make_pair(u,w));
67     }
68     printf("%d\n",tree_DC(1,n));
69   }
70   return 0;
71 }
```

13   zformula

13.1   formula.tex

13.1.1   Pick 公式

給定頂點坐標均是整點的簡單多邊形，面積 = 內部格點數 + 邊上格點數/2-1

13.1.2   圖論

1. $V - E + F = 2$
2. 對於平面圖，$F = E - V + n + 1$，n 是連通分量
3. 對於平面圖，$E \leq 3V - 6$
4. 對於連通圖 G，最大獨立點集的大小設為 I(G)，最大匹配大小設為 M(G)，最小點覆蓋設為 Cv(G)，最小邊覆蓋設為 Ce(G)。對於任意連通圖：

   (a) $I(G) + Cv(G) = |V|$
   (b) $M(G) + Ce(G) = |V|$

5. 對於連通二分圖：

   (a) $I(G) = Cv(G)$
   (b) $M(G) = Ce(G)$

6. 最大權閉合圖：

   (a) $C(u,V) = \infty, (u,v) \in E$
   (b) $C(S,v) = W_v, W_v > 0$
   (c) $C(v,T) = -W_v, W_v < 0$

7. 最大密度子圖：

   (a) $C(u,v) = 1, (u,v) \in E$
   (b) $C(S,v) = U_v, v \in V$
   (c) $C(v,T) = U + 2g - d_v, v \in V$

8. 弦圖：

   (a) 完美消除序列從後往前依次給每個點染色，給每個點染上可以染的最小顏色
   (b) 最大團大小 = 色數
   (c) 最大獨立集: 完美消除序列從前往後能選就選
   (d) 最小團覆蓋: 最大獨立集的點和他延伸的邊構成
   (e) 區間圖是弦圖
   (f) 區間圖的完美消除序列: 將區間按造又端點由小到大排序
   (g) 區間圖染色: 用線段樹做

```cpp
1  double l=0,=m,stop=1.0/n/n;
2  while(r-l>=stop){
3    double(mid);
4    if((n*m-sol.maxFlow(s,t))/2>eps)l=mid;
5    else r=mid;
6  }
7  build(l);
8  sol.maxFlow(s,t);
9  vector<int> ans;
10 for(int i=1;i<=n;++i)
11   if(sol.vis[i])ans.push_back(i);
```

13.1.3 學長公式

1. $\sum_{d|n} \phi(n) = n$
2. $g(n) = \sum_{d|n} f(d) \Rightarrow f(n) = \sum_{d|n} \mu(d) \times g(n/d)$
3. Harmonic series $H_n = \ln(n) + \gamma + 1/(2n) - 1/(12n^2) + 1/(120n^4)$
4. $\gamma = 0.5772156649015328606065120900824024310 4215$
5. 格雷碼 $= n \oplus (n >> 1)$
6. $SG(A + B) = SG(A) \oplus SG(B)$
7. 選轉矩陣 $M(\theta) = \begin{pmatrix} cos\theta & -sin\theta \\ sin\theta & cos\theta \end{pmatrix}$

13.1.4 基本數論

1. $\sum_{d|n} \mu(n) = [n == 1]$
2. $g(m) = \sum_{d|m} f(d) \Leftrightarrow f(m) = \sum_{d|m} \mu(d) \times g(m/d)$
3. $\sum_{i=1}^{n} \sum_{j=1}^{m}$ 互質數量 $= \sum \mu(d) \lfloor \frac{n}{d} \rfloor \lfloor \frac{m}{d} \rfloor$
4. $\sum_{i=1}^{n} \sum_{j=1}^{n} lcm(i,j) = n \sum_{d|n} d \times \phi(d)$

13.1.5 排組公式

1. k 卡特蘭 $\frac{C_n^{kn}}{n(k-1)+1} \cdot C_m^n = \frac{n!}{m!(n-m)!}$
2. $H(n,m) \cong x_1 + x_2 \dots + x_n = k, num = C_k^{n+k-1}$
3. Stirling number of 2nd, n 人分 k 組方法數目
   (a) $S(0,0) = S(n,n) = 1$
   (b) $S(n,0) = 0$
   (c) $S(n,k) = kS(n-1,k) + S(n-1,k-1)$
4. Bell number, n 人分任意多組方法數目
   (a) $B_0 = 1$
   (b) $B_n = \sum_{i=0}^{n} S(n,i)$
   (c) $B_{n+1} = \sum_{k=0}^{n} C_k^n B_k$
   (d) $B_{p+n} \equiv B_n + B_{n+1} mod p$, p is prime
   (e) $B_{p^m+n} \equiv mB_n + B_{n+1} mod p$, p is prime
   (f) From $B_0 : 1, 1, 2, 5, 15, 52, 203, 877, 4140, 21147, 115975$
5. Derangement, 錯排, 沒有人在自己位置上
   (a) $D_n = n!(1 - \frac{1}{1!} + \frac{1}{2!} - \frac{1}{3!} \dots + (-1)^n \frac{1}{n!})$
   (b) $D_n = (n-1)(D_{n-1} + D_{n-2}), D_0 = 1, D_1 = 0$
   (c) From $D_0 : 1, 0, 1, 2, 9, 44, 265, 1854, 14833, 133496$
6. Binomial Equality
   (a) $\sum_k \binom{r}{m+k} \binom{s}{n-k} = \binom{r+s}{m+n}$
   (b) $\sum_k \binom{l}{m+k} \binom{s}{n+k} = \binom{l+s}{l-m+n}$
   (c) $\sum_{k \leq l} \binom{l}{m+k} \binom{s+k}{n}(-1)^k = (-1)^{l+m} \binom{s-m}{n-l}$
   (d) $\sum_{k \leq l} \binom{l-k}{m} \binom{s}{k-n}(-1)^k = (-1)^{l+m} \binom{s-m-1}{l-n-m}$
   (e) $\sum_{0 \leq k \leq l} \binom{l-k}{m} \binom{q+k}{n} = \binom{l+q+1}{m+n+1}$
   (f) $\binom{r}{k} = (-1)^k \binom{k-r-1}{k}$

(g) $\binom{r}{m} \binom{m}{k} = \binom{r}{k} \binom{r-k}{m-k}$
(h) $\sum_{k \leq n} \binom{r+k}{k} = \binom{r+n+1}{n}$
(i) $\sum_{0 \leq k \leq n} \binom{k}{m} = \binom{n+1}{m+1}$
(j) $\sum_{k \leq m} \binom{m+r}{k} x^k y^k = \sum_{k \leq m} \binom{-r}{k}(-x)^k(x+y)^{m-k}$

13.1.6 冪次, 冪次和

1. $a^b \% P = a^{b\%\varphi(p)+\varphi(p)}, b \geq \varphi(p)$
2. $1^3 + 2^3 + 3^3 + \dots + n^3 = \frac{n^4}{4} + \frac{n^3}{2} + \frac{n^2}{4}$
3. $1^4 + 2^4 + 3^4 + \dots + n^4 = \frac{n^5}{5} + \frac{n^4}{2} + \frac{n^3}{3} - \frac{n}{30}$
4. $1^5 + 2^5 + 3^5 + \dots + n^5 = \frac{n^6}{6} + \frac{n^5}{2} + \frac{5n^4}{12} - \frac{n^2}{12}$
5. $0^k + 1^k + 2^k + \dots + n^k = P(k), P(k) = \frac{(n+1)^{k+1} - \sum_{i=0}^{k-1} C_i^{k+1} P(i)}{k+1}, P(0) = n+1$
6. $\sum_{k=0}^{m-1} k^n = \frac{1}{n+1} \sum_{k=0}^{n} C_k^{n+1} B_k m^{n+1-k}$
7. $\sum_{j=0}^{m} C_j^{m+1} B_j = 0, B_0 = 1$
8. 除了 $B_1 = -1/2$, 剩下的奇數項都是 0
9. $B_2 = 1/6, B_4 = -1/30, B_6 = 1/42, B_8 = -1/30, B_{10} = 5/66, B_{12} = -691/2730, B_{14} = 7/6, B_{16} = -3617/510, B_{18} = 43867/798, B_{20} = -174611/330,$

13.1.7 Burnside's lemma

1. $|X/G| = \frac{1}{|G|} \sum_{g \in G} |X^g|$
2. $X^g = t^{c(g)}$
3. G 表示有幾種轉法, X^g 表示在那種轉法下, 有幾種是會保持對稱的, t 是顏色數, $c(g)$ 是循環節不動的面數。
4. 正立方體塗三顏色, 轉 0 有 3^6 個元素不變, 轉 90 有 6 種, 每種有 3^3 不變, 180 有 3×3^4, 120(角) 有 8×3^2, 180(邊) 有 6×3^3, 全部 $\frac{1}{24}(3^6 + 6 \times 3^3 + 3 \times 3^4 + 8 \times 3^2 + 6 \times 3^3) = 57$

13.1.8 Count on a tree

1. Rooted tree: $s_{n+1} = \frac{1}{n} \sum_{i=1}^{n}(i \times a_i \times \sum_{j=1}^{\lfloor n/i \rfloor} a_{n+1-i \times j})$
2. Unrooted tree:
   (a) Odd: $a_n - \sum_{i=1}^{n/2} a_i a_{n-i}$
   (b) Even: $Odd + \frac{1}{2} a_{n/2}(a_{n/2} + 1)$
3. Spanning Tree
   (a) 完全圖 $n^n - 2$
   (b) 一般圖 (Kirchhoff's theorem) $M[i][i] = degree(V_i), M[i][j] = -1$, if have $E(i,j)$, 0 if no edge. delete any one row and col in A, $ans = det(A)$

13.2 java.tex

13.2.1 文件操作

```java
import java.io.*;
import java.util.*;
import java.math.*;
import java.text.*;

public class Main{

    public static void main(String args[]){
        throws FileNotFoundException,
        IOException
        Scanner sc = new Scanner(new FileReader(
            "a.in"));
        PrintWriter pw = new PrintWriter(new
            FileWriter("a.out"));
        int n,m;
        n=sc.nextInt();//读入下一个INT
        m=sc.nextInt();

        for(ci=1; ci<=c; ++ci){
            pw.println("Case #"+ci+": easy for
                output");
        }

        pw.close();//关闭流并释放, 这个很重要,
            否则是没有输出的
        sc.close();//关闭流并释放
    }
}
```

13.2.2 优先队列

```java
PriorityQueue queue = new PriorityQueue( 1,
    new Comparator(){
    public int compare( Point a, Point b ){
    if( a.x < b.x || a.x == b.x && a.y < b.y )
        return -1;
    else if( a.x == b.x && a.y == b.y )
        return 0;
    else return 1;
    }
});
```

13.2.3 Map

```java
Map map = new HashMap();
map.put("sa","dd");
String str = map.get("sa").toString;

for(Object obj : map.keySet()){
    Object value = map.get(obj );
}
```

13.2.4 sort

```java
static class cmp implements Comparator{
    public int compare(Object o1,Object o2){
    BigInteger b1=(BigInteger)o1;
    BigInteger b2=(BigInteger)o2;
    return b1.compareTo(b2);
    }
}
public static void main(String[] args)
        throws IOException{
    Scanner cin = new Scanner(System.in);
    int n;
    n=cin.nextInt();
    BigInteger[] seg = new BigInteger[n];
    for (int i=0;i<n;i++)
    seg[i]=cin.nextBigInteger();
    Arrays.sort(seg,new cmp());
}
```

14

14.1 ganadoQuote.cpp

```
¡Allí está!
¡Un forastero!
¡Agarrenlo!
¡Os voy a romper a pedazos!
¡Cógelo!
¡Te voy a hacer picadillo!
¡Te voy a matar!
¡Míralo, está herido!
¡Sos cerdo!
¿Dónde estás?
¡Detrás de tí, imbécil!
¡No dejes que se escape!
¡Basta, hijo de puta!
Lord Saddler...

¡Mátalo!
¡Allí está!
Morir es vivir.
Síííí, ¡Quiero matar!
Muere, muere, muere....
Cerebros,cerebros,cerebros...
Cógedlo, cógedlo, cógedlo...
Lord Saddler...
Dieciséis.

¡Va por él!
¡Muérete!
¡Cógelo!
¡Te voy a matar!
¡Bloqueale el paso!
¡Te cogí!
¡No dejes que se escape!

¿Qué carajo estás haciendo aquí? ¡Lárgate,
    cabrón!
```

```
35 Hay un rumor de que hay un extranjero entre
        nosotros.
36 Nuestro jefe se encargará de la rata.
37 Su "Las Plagas" es mucho mejor que la
        nuestra.
38 Tienes razón, es un hombre.
39 Usa los músculos.
40 Se vuelve loco!
41 ¡Hey, acá!
42 ¡Por aquí!
43 ¡El Gigante!
44 ¡Del Lago!
45 ¡Cógelo!
46 ¡Cógenlo!
47 ¡Allí!
48 ¡Rápido!
49 ¡Empieza a rezar!
50 ¡Mátenlos!
51 ¡Te voy a romper en pedazos!
52 ¡La campana!
53 Ya es hora de rezar.
54 Tenemos que irnos.
55 ¡Maldita sea, mierda!
56 ¡Ya es hora de aplastar!
57 ¡Mierda!
58 ¡Puedes correr, pero no te puedes esconder!
59 ¡Sos cerdo!
60 ¡Está en la trampa!
61 ¡Ah, que madre!
62 ¡Vámonos!
63 ¡Ándale!
64 ¡Cabrón!
65 ¡Coño!
66 ¡Agárrenlo!
67 Cógerlo, Cógerlo...
68 ¡Allí está, mátalo!
69 ¡No dejas que se escape de la isla vivo!
70 ¡Hasta luego!
71 ¡Rápido, es un intruso!
```

14.2   .cpp

```
 1 /************************
 2 L'Internationale,
 3     Sera le genre humain.
 4
 5               -. .
 6      _____  ','.','.
 7    ,'      ,'    ','. ',
 8    \      \       |' |
 9     \      \      |  |
10     \ /^\   \    ,'  ,'
11      \      \   ',  ,'
12      / ~-.___\.-'  ,'
13     /  '_____.- ~ |
14    /  /'          \  \
15    \./             \/'
16 ************************/
17 Вставай, проклятьем заклеймённый,
18 Весь мир голодных и рабов!
19 Кипит наш разум возмущённый
20 И в смертный бой вести готов.
21 Весь мир насилья мы разрушим
22 До основанья, а затем
23 Мы наш, мы новый мир построим, —
24 Кто был ничем, тот станет всем.
25
26 Chorus
27 Это есть наш последний
28 И решительный бой;
29 С Интернационалом
30 Воспрянет род людской!
31
32 Никто не даст нам избавленья:
33 Ни бог, ни царь и не герой!
34 Добьёмся мы освобожденья
35 Своею собственной рукой.
36 Чтоб свергнуть гнёт рукой умелой,
37 Отвоевать своё добро, —
38 Вздувайте горн и куйте смело,
39 Пока железо горячо!
40
41 Chorus
42
43 Довольно кровь сосать, вампиры,
44 Тюрьмой, налогом, нищетой!
45 У вас — вся власть, все блага мира,
46 А наше право — звук пустой !
47 Мы жизнь построим по-иному —
48 И вот наш лозунг боевой:
49 Вся власть народу трудовому!
50 А дармоедов всех долой!
51
52 Chorus
53
54 Презренны вы в своём богатстве,
55 Угля и стали короли!
56 Вы ваши троны, тунеядцы,
57 На наших спинах возвели.
58 Заводы, фабрики, палаты —
59 Всё нашим создано трудом.
60 Пора! Мы требуем возврата
61 Того, что взято грабежом.
62
63 Chorus
64
65 Довольно королям в угоду
66 Дурманить нас в чаду войны!
67 Война тиранам! Мир Народу!
68 Бастуйте, армии сыны!
69 Когда ж тираны нас заставят
70 В бою геройски пасть за них —
71 Убийцы, в вас тогда направим
72 Мы жерла пушек боевых!
73
74 Chorus
75
76 Лишь мы, работники всемирной
77 Великой армии труда,
78 Владеть землёй имеем право,
79 Но паразиты — никогда!
80 И если гром великий грянет
81 Над сворой псов и палачей, —
82 Для нас всё так же солнце станет
83 Сиять огнём своих лучей.
84
85 Chorus
```

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