Team Reference
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Contents

1. Estructura de Datos

1.1. Arbol Binario Indexado.

```
# include <cstdio>
 using namespace std;

 int tm, op, p;
 typedef long long ll;

 struct date{
   int save[10005];

   void update(int p, ll v){
      for(int i = p; i <= tm; i += i& -i)
         save[i] += v;
   }

   ll query(int p){
      int sum=0;
      for(int i = p; i > 0; i -= (i & -i))
         sum += save[i];
      return sum;
   }
}bit;

int main(){

  scanf("%d", &tm);
  while(1){

     scanf("%d %d", &op, &p);

     if(op == -1)
        return 0;

     if(op)
        bit.update(p);
     else
        bit.print(p);
  }

}
```

1.2. Segment Tree.

```
# include <iostream>
 # include <algorithm>
 # define oo 1 << 29
 # define RANG 30000000
 using namespace std;

 char c;
 int r1, r2, r3, i, Q;

 struct S_Tree{
   int n;
   int elements[5005];
   int T[RANG], Mk[RANG];

   int Build(int x, int xend, int P = 1){

      if(x == xend)
         return T[P] = elements[x];

      int pv = (x+xend)/2;
      return T[P] = Build(x, pv, P*2) + Build(pv+1, xend, P*2+1);
   }

   void Lazy_propagation(int x, int xend, int P){
      if(x == xend)
         return;

      int pv = (x+xend)/2;

      T[P*2] += (pv - x + 1)* Mk[P];
      T[P*2+1] += (xend - pv )* Mk[P];

      Mk[P*2] += Mk[P];
      Mk[P*2+1] += Mk[P];

      Mk[P] = 0;
```

```
   }

   int Query(int x, int xend, int P = 1){

      if(r2 < x || xend < r1)
         return 0;

      if(Mk[P])
         Lazy_propagation(x, xend, P);

      if(r1 <= x && xend <= r2)
         return T[P];

      int pv = (x+xend)/2;
      return Query(x, pv, P*2) + Query(pv+1, xend, P*2+1);
   }

   int Update(int x, int xend, int P = 1){

      if(Mk[P])
         Lazy_propagation(x, xend, P);

      if(r2 < x || xend < r1)
         return T[P];

      if(r1 <= x && xend <= r2){
         Mk[P] += r3;
         T[P] += ((xend-x)+1)*r3;
         return T[P];
      }

      int pv = (x+xend)/2;
      return T[P] = Update(x, pv, P*2) + Update(pv+1, xend, P*2+1);
   }
}St;

int main(){
   cin >> St.n;
   for(i = 1; i <= St.n; i++)
      cin >> St.elements[i];
  St.Build(1, St.n);
   cin >> Q;
   while(Q--){
      cin >> c >> r1 >> r2;
      if(c == 'Q')
         cout << St.Query(1, St.n) << endl;
      else{
         cin >> r3;
         St.Update(1, St.n);
      }
   }

return 0; }
```

1.3. **Range Min-Max Quering.**

```
# include <cstdio>
 # include <cmath>
 # include <algorithm>
 using namespace std;

 int mat[5005][20];
 int n, p2, p1, q;

 void Build_RMQ(){

   int cc = (int) log2(n);
   int p = n, a, i, j;
   for(i = 1; i <= cc; i++){
      a = 1 << (i-1);
      p -= a;
      for(j = 1; j <= p; j++)
         mat[j][i] = min(mat[j][i-1], mat[j+a][i-1]);
   }
}

void find_RMQ(){
     int c = (int)log2(p2-p1);
     printf("%d\n", min(mat[p1][c], mat[p2-(1<<c)+1][c]));
}

int main(){


   scanf("%d %d", &n, &q);
   for(int i = 1; i <= n; i++)
      scanf("%d", &mat[i][0]);
```

```
   Build_RMQ();

   while(q--){
      scanf("%d %d", &p1, &p2);
      find_RMQ();
   }

 return 0;
}
```

1.4. Lowest Comon Antecesor.

```
# include <bits/stdc++.h>
 # define RANG 1000005
 using namespace std;

 int i, cn, q, x, y;
 vector <int> v[RANG];

 struct LCA {
   int T[100005][20], L[100005];

   void DFS(int np, int prev){
      L[np] = L[prev]+1;
      int l = v[np].size();
      for(int i = 0; i < l; i++){
         int nh = v[np][i];
         if(nh != prev)
            DFS(nh, np);
      }
    }

   void BFS(int np){
      queue <int> Q;
      Q.push(np);
      L[np] = 1;
      int l, nh;
      while(!Q.empty()){
         np = Q.front();
         Q.pop();

         l = v[np].size();
         for(int i = 0; i < l; i++){
            nh = v[np][i];
            if(L[nh] == 0){
               L[nh] = L[np]+1;
               Q.push(nh);
            }
         }
      }

   }

   void Build(int n){
      BFS(1);
      int lg = log2(n);
      for(int j = 1; j <= lg; j++)
         for(int i = 1; i <= n; i++)
            if(T[i][j-1] != -1)
               T[i][j] = T[T[i][j-1]][j-1];
   }

    int Query(int x, int y){
      int sol = 0;
      if(L[x] < L[y])swap(x, y);

      int lg = (int)log2(L[x]);
      for(int i = lg; i >= 0; i--)
         if(L[x] - (1 << i) >= L[y] && T[x][i])
            x = T[x][i], sol += (1 << i);

      if(x == y)return sol;

      for(int i = lg; i >= 0; i--)
         if(T[x][i] != T[y][i] && T[x][i])
            x = T[x][i], y = T[y][i], sol += (1 << i);

      return sol+2;
      return T[x][0];
    }
}Lc;

int main(){

   scanf("%d", &cn);
   for(i = 2; i <= cn; i++){//Leyendo padre
      scanf("%d", &Lc.T[i][0]);
      v[Lc.T[i][0]].push_back(i);
   }
```

```
   Lc.Build(cn);
   scanf("%d", &q);
   while(q--){
      scanf("%d %d", &x, &y);
      printf("%d\n", Lc.Query(x, y));
   }
```

1.5. Heavy Ligth Descomposition+Segmente Tree+Lowest Common Antecesor.

```
# include <bits/stdc++.h>
using namespace std;
typedef pair<int, int> par;

vector <par> v[10005];
vector <int> indx[10005];
int subsize[10005], chainHead[10005], chainIndx[10005];
int posInBase[10005], otherEnd[10005], chainNo, cont;

St -> estructura segment tree. Build-Query-Update+Lazy Propagation
LC -> Lowest Common Antecesor. Level[n], T[n][log n]. Build-Query
//Inicializar Level y subsize
 void DFS(int np, int prev, int depth = 0){
   Lc.Level[np] = depth;
   Lc.T[np][0] = prev;
   subsize[np] = 1;
   int l = v[np].size();
   for(int i = 0; i < l; i++){
      int nh = v[np][i].first;
      if(nh != prev){
         otherEnd[indx[np][i]] = nh;
         DFS(nh, np, depth+1);
         subsize[np] += subsize[nh];
      }
   }
 }
//Descomposition Hevy Ligth
 void HDL(int np, int nc, int prev){
   if(chainHead[chainNo] == -1)
      chainHead[chainNo] = np;

   chainIndx[np] = chainNo;
   posInBase[np] = cont;
Posicion que sera usada en el Segment Tree
   St.elements[cont++] = nc;

   int nh = -1, newc, l = v[np].size();
   for(int i = 0; i < l; i++){
      if(v[np][i].first == prev)continue;
      if(nh == -1 || subsize[nh] < subsize[v[np][i].first]){
         nh = v[np][i].first;
         newc = v[np][i].second;
      }
   }
   if(nh != -1)
      HDL(nh, newc, np);

   for(int i = 0; i < l; i++)
      if(nh != v[np][i].first && v[np][i].first != prev){
         chainNo++;
         HDL(v[np][i].first, v[np][i].second, np);
      }

}
 int query_up(int u, int v){
   int uchain = chainIndx[u], vchain = chainIndx[v], ans = -1;

   while(uchain != vchain){
      ans = max(ans, St.query(0, cont-1, 1, posInBase[chainHead[uchain]],
                              posInBase[u]));
      u = Lc.T[chainHead[uchain]][0];
      uchain = chainIndx[u];
   }

   ans = max(ans, St.query(0, cont-1, 1, posInBase[v]+1, posInBase[u]));

   return ans;
}
int query(int x, int y){
   int lca = Lc.Query(x, y);
   return max(query_up(x, lca), query_up(y, lca));
}
void update(int i, int val){
   int x = otherEnd[i];
   x = posInBase[x];
   St.elements[x] = val;
   St.update(0, cont-1, 1, x);
}
```

```
int n, i, a, b, c, tc;
char arr[50];

int main(){
     scanf("%d", &n);
     cont = 0;
     for(i = 1; i < n; i++){
        scanf("%d %d %d", &a, &b, &c);
        v[a].push_back((par){b, c});
        v[b].push_back((par){a, c});
        indx[a].push_back(i);
        indx[b].push_back(i);
     }

     fill(chainHead, chainHead+10002, -1);
     chainNo = 0;
     DFS(1, -1);
     HDL(1, -1, -1);
     St.Build(0, cont-1);
     Lc.Build(n);
}
```

1.6. Centroid Descomposition+Lowest Common Antecesor.

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

const int oo = 1 << 30;
int subsize[100005], Ant[100005], sol[100005], ref_pos, n, x, y;
vector <int> v[100005];
bool mk[100005];

void DFS1(int np, int prev){
  subsize[np] = 1;
  int l = v[np].size();
  for(int i = 0; i < l; i++){
     int nh = v[np][i];
     if(nh != prev && !mk[nh]){
        DFS1(nh, np);
        subsize[np] += subsize[nh];
     }
  }
}

int DFS2(int np, int prev){

   int l = v[np].size();
   for(int i = 0; i < l; i++){
     int nh = v[np][i];
     if(nh != prev && !mk[nh] && subsize[nh] > subsize[ref_pos]/2)
        return DFS2(nh, np);
   }
   return np;
}

void Descomposition(int root, int prev){
  ref_pos = root;
  DFS1(root, root);
  int centroid = DFS2(root, root);
  Ant[centroid] = prev;
  mk[centroid] = true;
  int l = v[centroid].size();
  for(int i = 0; i < l; i++){
     int nh = v[centroid][i];
     if(!mk[nh])
        Descomposition(nh, centroid);
  }
}
// LC -> tipo LCA, buscar implementacion arriba.

void Update(int x){
  int y = x;
  while(y > 0){
     sol[y] = min(sol[y], Lc.Query(x, y));
     y = Ant[y];
  }
}

int Query(int x){
  int y = x, ans = oo;
  while(y > 0){
     ans = min(ans, Lc.Query(y, x)+sol[y]);
     y = Ant[y];
  }
  return ans;
}
int Q;
```

```
int main(){

  scanf("%d %d", &n, &Q);
  for(int i = 1; i < n; i++){
     scanf("%d %d", &x, &y);
     v[x].push_back(y);
     v[y].push_back(x);
  }

  fill(sol, sol+n+1, oo);
  Lc.Build(n);
  Descomposition(1, -1);
  Update(1);

  while(Q--){
     scanf("%d %d", &x, &y);
     if(x == 1)
        Update(y);
     else
        printf("%d\n", Query(y));

  }
return 0;
}
```

1.7. **Trie.**

```
# include <cstdio>
# include <cstring>
using namespace std;

int n, q, i, j, ls, sol;
char s[505];

struct Trie{
  Trie *son[255];
  int end;
}T, *p = &T;

int main(){

  scanf("%d", &n);
  for(i = 1; i <= n; i++){
     scanf("%s", &s);
     ls = strlen(s);
     p = &T;
     for(j = 0; j < ls; j++){
        if(p -> son[s[j]] == NULL)
           p -> son[s[j]] = new Trie();
        p = p -> son[s[j]];
     }
  }


scanf("%d", &q);
  for(i = 1; i <= q; i++){
     scanf("%s", &s);
     ls = strlen(s);
     p = &T;
     for(j = 0; j < ls; j++){
        if(p -> son[s[j]] == NULL)
           break;
        p = p -> son[s[j]];
        if(j == ls-1)
           sol++;
     }
  }

  printf("%d", sol);
return 0;
}
```

2. Grafos & Flow

2.1. **Articulations Points.**

```
# include <cstdio>
# include <vector>
# include <algorithm>
using namespace std;
```

```
vector <int> v[505];
int low[505], D[505], x, y, cn, cc, l;
bool mk[505];

void Apoint(int node){
low[node] = D[node] = ++l;
int ls = v[node].size();
for(int i = 0; i < ls; i++){
      int next = v[node][i];
      if(!low[next]){
            Apoint(next);
            low[node] = min(low[node], low[next]);
            if( (D[node] == 1 && D[next] > 2) ||
                  (low[next] >= D[node] && D[node] != 1) )
                  mk[node] = true;
      }
      else
            low[node] = min(low[node], D[next]);
}
}
int main(){

scanf("%d %d", &cn, &cc);
for(int i = 1; i <= cc; i++){
      scanf("%d %d", &x, &y);
      v[x].push_back(y);
      v[y].push_back(x);
}

Apoint(1);

for(int i = 1; i <= cn; i++)
      if(mk[i])
            printf("%d\n", i);
}
```

2.2. Brigdes.

```
# include <vector>
# include <cstdio>
# define RANG 5005

using namespace std;

struct par{
      int np, nh;
      bool mk;

      int next(int x){
            if(x == np)
                  return nh;
            return np;
      }
}A[RANG];

int cc, i, L, x, y;
int Low[RANG], T[RANG];
vector <int> v[RANG];

void Brigdes(int np){
T[np] = Low[np] = ++L;
int l = v[np].size();

for(int i = 0; i < l; i++){
      int nh = A[ v[np][i] ].next(np);

      if(!T[nh]){
            A[ v[np][i] ].mk = true;
            Brigdes(nh);
            Low[np] = min(Low[nh], Low[np]);
            if(Low[nh] > T[np])
                  printf("%d %d\n", np, nh);
      }
      else
            if(!A[v[np][i]].mk)
                  Low[np] = min(Low[np], T[nh]);

}
}

int main(){

      scanf("%d", &cc);
      for(i = 1; i <= cc; i++){
            scanf("%d %d", &x, &y);
            A[i] = (par){x, y};
            v[x].push_back(i);
            v[y].push_back(i);
```

```
      }

      Brigdes(1);
```

2.3. Strong Connect Component.

```
# include <stack>
# include <vector>
# include <cstdio>
# include <algorithm>
using namespace std;

int T[5005], low[5005], L;
int x, y, cn, cc;
vector <int> v[5005];
stack <int> S;
bool mk[5005];

void SCC(int np){
      T[np] = low[np] = ++L;
      int l = v[np].size();
      S.push(np);
      for(int i = 0; i < l; i++){
            int nh = v[np][i];
            if(!T[nh]){
                  SCC(nh);
                  low[np] = min(low[nh], low[np]);
            }
            else
                  if(!mk[nh])
                        low[np] = min(T[nh], low[np]);
      }
      if(low[np] == T[np]){
            while(S.top() != np){
                  printf("%d ", S.top());
                  mk[S.top()] = true;
                  S.pop();
            }
            printf("%d\n", S.top());
            mk[S.top()] = true;
            S.pop();
      }
}

int main(){

      scanf("%d %d", &cn, &cc);
      for(int i = 1; i <= cc; i++){
            scanf("%d %d", &x, &y);
            v[x].push_back(y);
      }

      for(int i = 1; i <= cn; i++)
            if(!mk[i])
                  SCC(i);
      return 0;
}
```

2.4. Kruskal.

```
# include <queue>
# include <cstdio>
using namespace std;

int R[5005], Set[5005];
int i, x, y, z, n1, n2, sol, cn, cc;

struct par{
      int x, y, z;
      bool operator < (const par &a)
      const {
            return z > a.z;
      }
};

priority_queue <par> Q;

void make_set(){
      for(int i = 1; i <= cn; i++)
            R[i] = 1, Set[i] = i;
```

```
}

int find_set(int x){
      if(x != Set[x])
            return Set[x] = find_set(Set[x]);
      return x;
}

void join_set(){
      if(R[n1] > R[n2])
            Set[n2] = n1, R[n1] += R[n2];
      else
            Set[n1] = n2, R[n2] += R[n1];
}

int main(){

      freopen("kruskal.in", "r", stdin);
      freopen("kruskal.out", "w", stdout);

      scanf("%d␣%d", &cn, &cc);
      for(i = 1; i <= cc; i++){
            scanf("%d␣%d␣%d", &x, &y, &z);
            Q.push((par){x, y, z});
      }

      make_set();
      for(; !Q.empty(); Q.pop()){
            n1 = find_set(Q.top().x);
            n2 = find_set(Q.top().y);
            if(n1 != n2)
                  sol += Q.top().z,
                  join_set();
      }

      printf("%d", sol);

      return 0;
}
```

2.5. Prim.

```
# include <queue>
# include <vector>
# include <cstdio>
using namespace std;

struct par {
      int n1, n2;
      bool operator < (const par &a)
      const {
            return n2 > a.n2;
      }
};

bool mk[5005];
int np, nh, nc, ch, i, l, x, y, z, sol, cn, cc;
vector <par> v[5005];
priority_queue <par> Q;

int main(){

      scanf("%d␣%d", &cn, &cc);

      for(i = 1; i <= cc; i++){
            scanf("%d␣%d␣%d", &x, &y, &z);
            v[x].push_back((par){y, z});
            v[y].push_back((par){x, z});
      }

      for(Q.push((par){1, 0});
            !Q.empty();
            Q.pop()){

            np = Q.top().n1;
            nc = Q.top().n2;
            l = v[np].size();

            if(mk[np])continue;
            mk[np] = true;
            sol += nc;

            for(i = 0; i < l; i++){
                  nh = v[np][i].n1;
                  ch = v[np][i].n2;
                  if(!mk[nh])
                        Q.push((par){nh, ch});
            }
```

```
      }

      printf("%d", sol);
```

2.6. K-th Camino Mínimo.

```
# include <queue>
# include <vector>
# include <cstdio>
# define RANG 5005
using namespace std;

struct par {
      int x, y;
      bool operator > (const par &a)
      const {
            return y > a.y;
      }
};

vector <par> v[RANG];
priority_queue <par, vector<par>, greater<par> > Q;
int End, cc, i, x, y, z, np, nh, nc, hc, l, k;
int V[RANG];

int k_th(){

      for(Q.push((par){1, 0}); !Q.empty(); ){
            np = Q.top().x;
            nc = Q.top().y;
            Q.pop();
            l = v[np].size();
            V[np]++;
            if(np == End){
                  if(V[np] == k)return nc;
            }

            for(i = 0 ; i < l; i++){
                  nh = v[np][i].x;
                  hc = v[np][i].y;
                  if(V[nh] < k)
                        Q.push((par){nh, nc+hc});
            }
      }
}

int main(){

      scanf("%d %d %d", &cc, &End, &k);
      for(i = 1; i <= cc; i++){
            scanf("%d %d %d", &x, &y, &z);
            v[x].push_back((par){y, z});
            v[y].push_back((par){x, z});
      }

      printf("%d", k_th());

      return 0;
}
```

2.7. Floyd Warshall.

```
# include <cstdio>
using namespace std;

int cn, cc, i, j, k, x, y, z;
int map[305][305];

int main(){

      scanf("%d %d", &cn, &cc);

      for(i = 1; i <= cc; i++){
            scanf("%d %d %d", &x, &y, &z);
            if(map[x][y] == 0 || map[x][y] > z)
                  map[x][y] = z;
            if(map[y][x] == 0 || map[y][x] > z)
                  map[y][x] = z;
      }

      for(k = 1; k <= cn; k++)
            return 0;
}
```

```
      for(i = 1; i <= cn; i++)
            if(map[i][k] > 0){
              for(j = 1; j <= cn; j++){
                    if(map[k][j] == 0)
                          continue;
                    if(map[i][j] == 0 || map[i][j] > map[i][k]+map[k][j])
                          map[i][j] = map[i][k]+map[k][j];
                }
                }
```

2.8. **Camino Circuito Eureliano.**

```
# include <queue>
# include <vector>
# include <cstdio>

using namespace std;

struct tri{
  int np, nh;
  bool mk;

  int next(int x){
     if(x == np)
        return nh;
     return np;
  }
}A[5005];

int ini = 1, i, j, x, y, c, cn, cc, C[5005];
vector <int> v[5005];
queue <int> Q;

void Euler(int np){
   int ls = v[np].size();
   for(int i = 0; i < ls; i++){
      int p = v[np][i];
      if(!A[p].mk){
        A[p].mk = true;
        Euler(A[p].next(np));
      }
  }
  Q.push(np);
}

int main(){
   scanf("%d %d", &cn, &cc);
   for(i = 1; i <= cc; i++){
      scanf("%d %d", &x, &y);
      A[i] = (tri){x, y, false};
      v[x].push_back(i);
      v[y].push_back(i);
      C[x]++;
      C[y]++;
   }

      for(i = 1; i <= cn; i++)
      if(C[i] % 2 == 1)
         c++,
         ini = i;

   if(c > 2){
      printf("No es camino, ni circuito");
      return 0;
   }

   if(c == 2)
      printf("Es camino\n");

   if(c == 0)
      printf("Es circuito\n");

   Euler(ini);

   for(;!Q.empty(); Q.pop())
      printf("%d\n", Q.front());

      return 0;
}
```

```
      for(i = 1; i <= cn; i++){
            for(j = 1; j <= cn; j++)
                  if(map[i][j] == 0)
                        printf("? ");
                  else
                        printf("%d ", map[i][j]);
            printf("\n");
      }
}
```

2.9. **Ford Fulkerson.**

```
# include <queue>
# include <cstdio>
# include <vector>
# include <algorithm>
# define oo 1 << 29

using namespace std;

int sr, sk, n, m, x, y, z, np, nh, cp, p, l, i, max_flow, b;
int Flow[105][105], Fr[105];
bool mk[105];

vector <int> v[105];

int aug_path(){
      priority_queue <pair<int, int> > Q;

      fill(Fr, Fr+n+1, -1);
      fill(mk, mk+n+1, false);
      mk[sr] = true;
      Q.push(make_pair(oo, sr));
      b = 0;

      while(!Q.empty()){
            cp = Q.top().first;
            np = Q.top().second;
            Q.pop();

            if(np == sk){
                        b = max(b, cp);
                  break;
            }

            l = v[np].size();
            for(i = 0; i < l; i++){
                  nh = v[np][i];
                  if(!mk[nh] && Flow[np][nh]){
                        mk[nh] = true;
                        Fr[nh] = np;
                        Q.push(make_pair(min(cp, Flow[np][nh]), nh));
                  }
            }
      }

      nh = sk;
      while(Fr[nh] != -1){
            np = Fr[nh];
            Flow[np][nh] -= b;
            Flow[nh][np] += b;
            v[nh].push_back(np);
            nh = np;
      }

      return b;
}

int main(){

      scanf("%d %d %d %d", &n, &m, &sr, &sk);

      for(i = 1; i <= m; i++){
            scanf("%d %d %d", &x, &y, &z);
            v[x].push_back(y);
            Flow[x][y] = z;
      }

      //while(p = aug_path()) max_flow += p;
      max_flow = aug_path();
      printf("%d\n", max_flow);

      return 0;
}
```

2.10. **Flujo Máximo Costo-Costo Mínimo.**

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

typedef long long ll;

using namespace std;

int n;
```

```
struct nod{
      ll x,y,h;
      int id;
}N[505];

vector<int> v[505];

ll dist(nod a,nod b){
      if(a.id == 0 || b.id == 0 || a.id == n+1 || b.id == n+1)return 0;
      return (b.x - a.x)*(b.x - a.x) + (b.y - a.y)*(b.y - a.y) + (b.h - a.h)*(b.h - a.h);
}

int cap[505][505],tipo[505];
double costo[505][505],res;
vector<int> ady[505];
int from[505];
double d[505];

struct nodo{
      int id,parent;
      double costo;
      bool operator<(const nodo& a)const{
         return costo > a.costo;
      }
};

bool town[505];
double cost[505];
bool visited[505];
bool spring[505];
int s,t,cn;
double valor[505][505];

int augment1(int source, int sink){

      fill(from,from+sink+1,-1);
      fill(d,d+sink+1,99999999.0);
      fill(mk,mk+sink+1,0);

      d[source] = 0;
      bool x = 0;
      bool y = 0;

      for(int i = 1; i <= cn; i++){
            for(int h = 0; h < cn ; h++){
                  int no = tipo[h];
                  int len = v[no].size();
                  for(int k = 0; k < len; k++){
                        int m = v[no][k];
                        if(cap[no][m] && d[m] > d[no] + costo[no][m]){
                              d[m] = d[no] + costo[no][m];
                              from[m] = no;
                              y = 1;
                              if(m == sink)x = 1;
                        }
                  }
            }
            if(!y)break;
      }

      if(!x)return 0;

      int actual = sink;
      res+=d[sink];

      while(from[actual]!=-1){
            cap[actual][from[actual]]++;
            cap[from[actual]][actual]--;
            actual = from[actual];
      }
      return 1;
}

int max_flow(int sink,int source){
      int r = 0;
      while(1){
         if(augment1(sink,source))r++;
         else return r;
      }
}

int main(){

   int a;
   ll q;

   scanf("%d %d %d %I64d",&n,&s,&t,&q);

   N[0].id = 0;
   N[n+1].id = n+1;

   for(int i = 1; i <= n; i++){
      scanf("%I64d %I64d %I64d",&N[i].x,&N[i].y,&N[i].h);
      N[i].id = i;
```

```
      for(int h = 1; h < i; h++){
            // cout<<"d "<<dist(N[i],N[h])<<endl;
               ll g = dist(N[i],N[h]);
               valor[i][h] = valor[h][i] = sqrt((double)g);

         if(g <= q*q && N[i].h > N[h].h){
            ady[i].push_back(h);
         }

         if(g <= q*q && N[i].h < N[h].h){
            ady[h].push_back(i);
         }
      }
   }

   for(int i = 0; i < s; i++){
      scanf("%d",&a);
      tipo[++cn] = a;
      cap[0][a] = 1;
      v[0].push_back(a);
      spring[a] = 1;
   }

   for(int i = 0; i < t; i++){
      scanf("%d",&a);
      cap[a][n+1] = 1;
      v[a].push_back(n+1);
      town[a] = 1;
      tipo[++cn] = a;
   }

   cn++;
   tipo[cn] = n+1;
   for(int i = 1; i <= n; i++){
      if(spring[i]){
         dijkstra(i);
      }
   }

   int k = max_flow(0,n+1);

   if(k < t)printf("IMPOSSIBLE\n");
   else{
      printf("%lf\n",res);
   }

   return 0;
}
```

2.11. **Hungarian Algorithm.**

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

const int MAXN = 105;
const int INF = 1000 * 1000 * 1000;

int n;
int a[MAXN][MAXN];
int u[MAXN], v[MAXN], link[MAXN], par[MAXN], used[MAXN], minval[MAXN];

int main() {

      scanf("%d", &n);
      for (int i = 1; i <= n; i++)
            for (int j = 1; j <= n; j++)
                  scanf("%d", &a[i][j]);

      for (int i = 1; i <= n; i++) {
            for (int j = 0; j < MAXN; j++) {
                  used[j] = false;
                  minval[j] = INF;
            }

            int j_cur = 0;
            par[j_cur] = i;

            do {
                  used[j_cur] = true;
                  int j_next, delta = INF, i_cur = par[j_cur];

                  for (int j = 0; j <= n; j++)
                        if (!used[j]) {
                           int cur = a[i_cur][j] - u[i_cur] - v[j];
                              if (cur < minval[j]) {
                                    minval[j] = cur; link[j] = j_cur;
                              }
                              if (minval[j] < delta) {
                               delta = minval[j]; j_next = j;
```

```
                        }
                    }

                for (int j = 0; j <= n; j++)
                    if (used[j]) {
                        u[par[j]] += delta; v[j] -= delta;
                    }
                    else {
                        minval[j] -= delta;
                    }
                    j_cur = j_next;
            } while (par[j_cur]);

            do {
                int j_prev = link[j_cur];
                par[j_cur] = par[j_prev];
                j_cur = j_prev;
            } while (j_cur > 0);
        }

        printf("%d", -v[0]);
        return 0;
    }
```

3. Geometry & Math

3.1. **Estructuras Geometricas.**

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

const double EPS = 0.000000001;

struct Point {
    double x, y;

    Point(double a = 0, double b=0){
        x = a; y = b;
    }

    double Dist(Point p1){
        return pow((pow(x-p1.x,2)+pow(y-p1.y, 2)), 1.0/2.0);
    }

    Point operator - (const Point &p)const{
        return Point(x-p.x, y-p.y);
    }

    Point operator + (const Point &p)const{
        return Point(x+p.x, y+p.y);
    }
};

struct Vector{
    double a, b;

    Vector (Point p1=Point(0, 0), Point p2=Point(0, 0)){
        a = p2.x-p1.x;
        b = p2.y-p1.y;
    }

    private: Vector Normal(){
        return Vector(a, -b);
    };
};

struct Recta{
    double A, B, C;

    Recta(Point p1, Point p2){
        Vector v = Vector(p1, p2);
        A = v.b;
        B = -v.a;
        C = v.a*p1.y - v.b*p1.x;
        Normalizar();
    }

    Recta(double a = 0, double b = 0, double c = 0){
        A = a;
        B = b;
        C = c;
        Normalizar();

    }
    ///Vector v, vetor normal a la recta
    ///que se quiere obtener
```

```
      void Recta1(Vector v, Point p){
            A = v.a;
            B = v.b;
            C = -A*p.x-B*p.y;
            Normalizar();
      }
      //Rectas Paralelas
      bool operator == (const Recta &P)const{
            return A==P.A && B == P.B;
      }

      private:

      void Normalizar(){
             if(A < 0)
                  A*=-1, B*=-1, C*=-1;
             if(A == 0 && B < 0)
                  B *= -1,C*= -1;
      }

      double Dist_Point(Point p){
            return abs(A*p.x+B*p.y+C)/pow(A*A+B*B, 1.0/2.0);
      }

      Point Intersection_Recta(Recta R2){
            Point p;
            Recta R1 = Recta(A, B, C);

            if(R1.A == 0)swap(R1, R2);
            p.y = (-R2.C*R1.A+R1.C*R2.A)/(R1.A*R2.B-R2.A*R1.B);
            p.x = (-R1.B*p.y-R1.C)/R1.A;

            return p;
      }
};

struct Circulo{
      double h, k, r;

      Circulo (Point p = Point(0, 0), double q = 0){
            h = p.x;
            k = p.y;
            r = q;
      }

      bool operator < (const Circulo &Q)const{
            if(h != Q.h)return h < Q.h;
            if(k != Q.k)return k < Q.k;
            return r < Q.r;
      }

      /// op-> diferenciar que punto devolver
      Point Interseccion_Recta(Recta R, int op){
            double x0 = -R.A*R.C/(R.A*R.A+R.B*R.B),
                  y0 = -R.B*R.C/(R.A*R.A+R.B*R.B);

            if (R.C*R.C > r*r*(R.A*R.A + R.B*R.B)+EPS)
                  return Point(-100000.0, -100000.0);
            else if (abs (R.C*R.C - r*r*(R.A*R.A+R.B*R.B)) < EPS) {
                  //puts ("1 point");
                  //cout << x0+h << ' ' << y0+k << '\n';
                  return Point(x0+h, y0+k);
            }
            else {
                  double d = r*r - R.C*R.C/(R.A*R.A+R.B*R.B);
                  double mult = sqrt (d / (R.A*R.A+R.B*R.B));
                  double ax,ay,bx,by;
                  ax = x0 + R.B * mult + h;
                  bx = x0 - R.B * mult + h;
                  ay = y0 - R.A * mult + k;
                  by = y0 + R.A * mult + k;

                  if(op == 1)
                        return Point(ax, ay);
                  else
                        return Point(bx, by);
            }
      }
      ///op >
      Point Interseccion_Circle(Circulo C, int op){
            return Interseccion_Recta(Recta(2.0*(C.h-h), 2.0*(C.k-k), -(C.h-h)*(C.
      }

      bool is_Interseccion_Circle(Circulo C){
            if((h-C.h)*(h-C.h)+(k-C.k)*(k-C.k) <= (r+C.r)*(r+C.r))
                  return true;
            return false;
      }

      bool is_Inside_Circle(Point p){
            if((p.x-h)*(p.x-h)+(p.y-k)*(p.y-k) <= r*r+EPS)
                  return true;
            return false;
      }
```

```
};
```

3.2. Convex Hull.

```
# include <cstdio>
# include <algorithm>
using namespace std;

typedef long long ll;
const long long RAN = 1000;

struct par{
     ll x, y;
     par (ll a = 0, ll b = 0){
         x = a;
         y = b;
     }
     bool operator <(const par &R)
     const{
         if (R.x != x)
            return R.x > x;
          else
            return R.y > y;
     }
};

int n, can, con;
int P[RAN];
par A[RAN];

ll sol(int a, int b, int c){
      return (A[b].x - A[a].x) * (A[c].y - A[a].y)-
           (A[b].y - A[a].y) * (A[c].x - A[a].x);
}
```

```
int main(){
}
```

```
main (){

     scanf ("%d", &n);

     for (int i = 1; i <= n; i++)
         scanf ("%lld %lld", &A[i].x, &A[i].y);

     sort (A + 1, A + n + 1);

     can++;
     for (int i = 1; i <= n; i++){
         while (can < con && sol (P[con-1], P[con], i) < 0)
               con--;
         con++;
         P[con] = i;
     }

     can = con;
     for (int i = n - 1; i >= 1; i--){
         while (can < con && sol (P[con-1], P[con], i) < 0)
               con--;
         con++;
         P[con] = i;
     }


     printf ("%d\n", --con);
     for (int i = 1; i <= con; i++)printf ("%lld %lld\n", A[P[i]].x, A[P[i]].y);
}
```

3.3. Closest Pair of Points.

```
# include <set>
# include <cstdio>
# include <cmath>
# include <algorithm>
using namespace std;
```

```
struct par {
      double x, y;
}a[5005], *l = &a[0];
```

```
struct cmp_x{
      bool operator () (const par &a, const par &b)
      const {
            return a.x < b.x;
      }
};

struct cmp_y{
      bool operator () (const par &a, const par &b)
      const {
            return a.y < b.y;
      }
};


double dist(par a, par b){
      return (double) sqrt( (a.x-b.x)*(a.x-b.x)+(a.y-b.y)*(a.y-b.y) );
}

int n;
double sol = 1 << 29;
multiset <par, cmp_y> Q;
multiset <par, cmp_y>::iterator lo, hi;

int main(){
      fscanf(fe, "%d", &n);
      for(int i = 0; i < n; i++)
            fscanf(fe, "%lf␣%lf", &a[i].x, &a[i].y);

      sort(a, a+n, cmp_x());

      for(par *i = &a[0]; i != &a[n]; i++){
            while(i -> x - l -> x >= sol)
                  Q.erase( Q.find(*l++) );

            lo = Q.lower_bound(
      (par) {i->x, i->y-sol} );
            hi = Q.upper_bound(
      (par) {i->x, i->y+sol} );


            for(; lo != hi; lo++)
                  sol = min(sol, dist(*lo, *i));

            Q.insert(*i);
      }

      fprintf(fs, "%.2lf", sol);
      return 0;
}
```

3.4. GCD – LCM – Extended GCD.

```
# include <cstdio>
 # include <iostream>
 # include <algorithm>
 using namespace std;

 int GCD(int a, int b){
   while(a){
      b %= a;
      swap(a, b);
   }
   return b;
 }

 int GCD_extended(int a, int b, int &x, int &y){
   if(a == 0 ){
      x = 0; y = 1;
      return b;
   }
   int x1, y1;
   int d = GCD_extended(b%a, a, x1, y1);
   x = y1 - (b/a) * x1;
   y = x1;
   return d;
 }

 int a, b, g, x, y;

 int main(){

   cin >> a >> b;

   g = GCD_extended(a, b, x, y);
   cout << x << "␣" << y << "␣"<< g << "␣" << endl;
 }
```

3.5. **Area de Union+Multi Set.**

```
# include <set>
# include <cmath>
# include <cstdio>
# include <algorithm>
# define oo 1 << 29
using namespace std;

struct par{
      int x1, y1, x2, y2;
      par (int a=0, int b=0, int c=0, int d=0){
       x1=a, y1=b, x2=c, y2=d;
      }
}A[1005];

struct tri {
      int x, e, p;
      tri (int a = 0, int b = 0, int c = 0){
            x = a, e = b, p = c;
      }
      bool operator < (const tri &a)const{
            return x < a.x;
      }
}S[2005];

struct par1{
      int y, e;
      par1(int a = 0, int b = 0){y = a, e = b;}
};

struct cmp_y{
       bool operator () (const par1 &a, const par1 &b)const{
            return a.y < b.y;
      }
};

multiset <par1, cmp_y> M;
multiset <par1, cmp_y>::iterator lo;

int n, x, y, z, w, L, l, i, s;
long long amount, sol;

int main(){

      scanf("%d", &n);
      for(i = 0; i < n; i++){
            scanf("%d %d %d %d", &x, &y,&z, &w);
            A[i] = par(x, y, z, w);
            S[2*i] = tri(x, 1, i);
            S[2*i+1] = tri(z, -1, i);
      }

      sort(S, S+2*n);
      amount = 0;

      for(i = 0; i <= 2*n; i++){

            if(S[i].e == -1){
                  M.erase(M.find((par1){A[S[i].p].y1, 1}));
                  M.erase(M.find((par1){A[S[i].p].y2, -1}));
            }
            else {
                  M.insert((par1){A[S[i].p].y1, 1});
                  M.insert((par1){A[S[i].p].y2, -1});
            }

            sol += amount*(long long )abs(S[i].x-S[i-1].x);

            amount = 0;
            for(lo = M.begin(); lo != M.end(); lo++){// amount
                  if(s == 0)
                    l = lo->y;
                  s += lo->e;
                  if(s == 0){
                        amount += (lo->y-l);
                  }
            }
      }

      printf("%lld", sol);
      return 0;
}
```

3.6. **Area de Union+Segment Tree.**

```
# include <cstdio>
# include <algorithm>
# define RANG 55000
# define oo 20000

using namespace std;

struct ct{
      int x1, y1, x2, y2;
      ct(int a=0, int b=0, int c=0, int d=0){
        x1 = a; y1 = b; x2 = c; y2 = d;
      }
}A[1005];

struct par{
      int x, e, p;
      par(int a=1, int b=1, int c=1){
            x = a, e = b, p = c;
      }
}event[2005];

struct cmp_x{
      bool operator () (const par &a, const par &b)const{
            return a.x < b.x;
      }
};
int a, b, n, i, x, y, z, w, sol;
int T[RANG*3+5], mk[RANG*3+5];

int update(int V, int x=1, int xend=RANG, int P=1){
      if(b < x || xend < a)
        return T[P];

      if(a <= x && xend <= b){
            mk[P] += V;
            if(!mk[P]){
                  if(x == xend)T[P] = 0;
                  else T[P] = T[P*2]+T[P*2+1];
            }
            else T[P] = xend-x+1;
      }
      if(x == xend)
        return T[P];
      int pv = (x+xend)/2;
      return T[P] = update(V, x, pv, P*2) + update(V, pv+1, xend, P*2+1);
}

int main(){

      scanf("%d", &n);
      for(i = 0; i < n; i++){
            scanf("%d %d %d %d", &x, &y, &z, &w);
            A[i] = ct(x+oo, w+oo, z+oo, y+oo);
            event[i*2] = par(x+oo, 1, i);
            event[i*2+1] = par(z+oo, -1, i);
      }

      sort(event, event+2*n, cmp_x());

      for(i = 0; i < 2*n; i++){
            sol += T[1]*(event[i].x-event[i-1].x);
            a = A[event[i].p].y1;
            b = A[event[i].p].y2-1;
            update(event[i].e);
      }

      printf("%d", sol);

      return 0;
}
```

3.7. **Factorizacion.**

```
# include <map>
# include <cstdio>
# include <algorithm>
using namespace std;

typedef long long ll;
int P[1000055], f[50], Div[50], D, x, F;

///Criba para descomponer en
///factores primos
```

```
void Criba(){
      int N = 1000007;
      for(int i = 4; i < N; i+=2)
            P[i] = 2;
      Prim[cont_Prim++] = 2;
      for(int i = 3; i*i < N; i += 2)
            if(!P[i]){
                  Prim[cont_Prim++] = i;
                  for(int j = i*i; j < N; j += 2*i)
                        P[j] = i;
            }
}

///Factorizacion
int Fact(int n){
      int F = 0;
      while(P[n]){
            f[F++] = P[n];
            n /= P[n];
      }
      f[F++] = n;
      sort(f, f+F);
      return F;
}
///Todos los divisores de un numero
void div(int v, int ini, int fin){
      if(ini == fin){
            Div[D++] = v;
            printf("%d\n", v);
      }
      else {

            int m;
            for(m = ini+1; m < fin && f[m] == f[ini]; m++);
            for(int i = ini; i <= m; i++){
                  div(v, m, fin);
                  v *= f[ini];
            }
      }
}

///Cantidad de divisores de un numero
int Euler(int n, int F){
      int c = f[0];
      int v = 0;
      for(int i = 1; i <= F; i++)
            if(f[i] != f[i-1]){
                  v += (c - c/f[i-1]);
                  c = f[i];
            }
            else
                  c *= f[i];
      return v;
}

///Inverso Modular
ll MD(ll A,ll B,ll C){//return (A/B)%C
      if(A%B == 0)
            return A/B;
      return (A+(C*MD(B-(A%B),C%B,B)))/B;
}

ll Divisor_Sumation(){
 ///Productoria
      (Prim[i]^(E[i]+1)-1)/(Prim[i]-1)
      sol = 1ll;
      for (int i = 1; i <= c && P[i] <= n; i++)
            sol = (sol*MD((MOD+pow(Prim[i],E[i]+1ll)-1)%MOD,(Prim[i]-1ll),MOD))%MO
      }
      ll Phi(ll n){
      if(n == 1)
        return 2;
      ll res = 1;
      for(int i = 0; i < cp && primes[i] <= n; i++){
                  ll k = 1;
                  ll c = 0;
            while(!(n%primes[i])){
                    n/=primes[i];
                    k*=primes[i];
                    c = (primes[i]-1);
            }
            k/=primes[i];
            if(c)
            res*=(k*c);
      }
      if(n>1)
        res*=(n-1);
      return res;
}

int main(){

      scanf("%d",&x);
      Criba();
```

```
      F = Fact(x);
      div(1, 0, F);

      printf("Euler␣%d\n", Euler(x, F));
```

3.8. Metodo de Gauss.

```
# include <cstdio>
using namespace std;

int N, i, j, k;
double M[305][305], sp;

int main(){

      scanf("%d", &N);
      for(i = 1; i <= N; i++)
            for(j = 1; j <= N+1; j++)
                  scanf("%lf", &M[i][j]);

      printf("----------------------\n");

      for(i = 1; i <= N; i++)
            for(j = i+1; j <= N; j++)
                  for(k = N+1; k >= i; k--)
                        M[j][k] = M[j][i]*M[i][k] - M[j][k]*M[i][i];


      for(i = N; i > 0; i--){
            sp = M[i][N+1];
            for(j = i+1; j <= N+1; j++)
                  sp -= M[i][j]*M[j][j];
            M[i][i] = sp/M[i][i];
      }

      for(i = 1; i <= N; i++)
            printf("%.0lf␣", M[i][i]);


      return 0;
}
```

3.9. Fibonacci Logaritmico.

```
# include <cstdio>
# include <cmath>
using namespace std;

int M[5][5][70], S[5][5], i, lg, a, b, c, d;
long long n;

int main(){

      M[1][1][0] = 0;
      M[1][2][0] = 1;
      M[2][1][0] = 1;
      M[2][2][0] = 1;

      for(i = 1; i <= 63; i++){
            M[1][1][i] = (M[1][1][i-1] * M[1][1][i-1] + M[1][2][i-1] * M[2][1][i-1])%10;
            M[1][2][i] = (M[1][1][i-1] * M[1][2][i-1] + M[1][2][i-1] * M[2][2][i-1])%10;
            M[2][1][i] = (M[2][1][i-1] * M[1][1][i-1] + M[2][2][i-1] * M[2][1][i-1])%10;
            M[2][2][i] = (M[2][1][i-1] * M[2][1][i-1] + M[2][1][i-1] * M[1][2][i-1
      }

      while(scanf("%lld", &n) != EOF){

            S[1][1] = S[2][2] = 1;
            S[1][2] = S[2][1] = 0;

            lg = (int) log2(n);
            for(i = 0; i <= lg; i++){
                  if(n & (1ULL << i)){
                        a = (S[1][1]*M[1][1][i]+S[1][2]*M[2][1][i])%10;
                        b = (S[1][1]*M[1][2][i]+S[1][2]*M[2][2][i])%10;
                        c = (S[2][1]*M[1][1][i]+S[2][2]*M[2][1][i])%10;
                        d = (S[2][1]*M[1][2][i]+S[2][2]*M[2][2][i])%10;
                        S[1][1] = a;
                        S[1][2] = b;
                        S[2][1] = c;
```

```
                        S[2][2] = d;
                  }

            }
```

3.10. **Binary Exponetation.**

```
# include <cstdio>
using namespace std;

int a, b;
const int MOD = 1000000007;

int binpow (int a, int n) {
      int res = 1;
      while (n) {
            if (n & 1)
                  res = (a*res)%MOD;
            a = (a*a)%MOD;
            n = n >> 1;
            /**Desplaza los bits a la
            derecha y desaparece el primero*/
      }

      return res;
}

int main(){

      while(1){
            scanf("%d %d", &a, &b);
            printf("%d\n", binpow(a, b));
      }

      return 0;
}
```

3.11. **Factorial Compactado.**

```
# include <iostream>
# include <cstdio>
# include <algorithm>
# define RANG 1000000
# define MOD 10
using namespace std;

int n, C, tmp, S;
int i, j, P[1000005], M[1000005], E[1000005];
string s;

int main() {

      //Criba, para descomponer en factores primos
      for(i = 4; i <= RANG; i += 2)P[i] = 2;
      for(i = 3; i*i <= RANG; i +=2)
            if(!P[i])
                  for(j = i*i; j <= RANG; j += 2*i)
                        P[j] = i;

      /**Variaciones sin repeticiones
      25'000'000, hasta mas**/

      scanf("%d %d", &n, &C);
      for(i = 1; i <= C; i++)
            scanf("%d",&M[i]);

      //Compactar factoriales
      // i! ^ E[i]
      E[n]++;
      for(i = 1; i <= C; i++){
            if(M[i] > 1)E[M[i]]--;
            M[i] = 0;
      }

      //Descompone el factorial en la productoria de sus terminos
      for(i = n-1; i >= 2; i--)
```

```
        E[i] += E[i+1];
    //Descomponer el factoria
    //en potencias de factores primos
    for(i = n; i >= 2; i--)
        if(P[i]){
            E[i/P[i]] += E[i];
          E[P[i]] +=E[i];
          E[i] = 0;
        }

    //Especificidad para eliminar los
    //ultimos digitos iguales a 0
    tmp = min(E[2], E[5]);
    E[2] -= tmp; E[5] -= tmp;

    //Calcular la Variacion expresada
    //en la productoria de factores primos
    S = 1;
    for(i = 2; i <= n; i++){
       S = (S * modexp(i, E[i])) % 10;
       E[i] = 0;
    }

    printf("%d\n", S);

    return 0;
}
```

4. String Algorithms

4.1. Palindromes 1.

```
//O(n^2)
# include <cstdio>
# include <cstring>
using namespace std;

int i, j, ls;
bool m[5005][5005];
char s[5005];

int main(){

    scanf("%s", s+1);

    ls = strlen(s+1);
    for(i = 1; i <= ls; i++)
        m[1][i] = true;

    for(i = 2; i <= ls; i++){
        for(j = i; j <= ls; j++)
            if(s[j] == s[j-i+1] && m[i-(i > 2? 2:1)][j-1])
                m[i][j] = true;
    }

    return 0;
}
```

4.2. Knutt Morris Pratt (Prefix Function).

```
/**
Determina las ocurrencias de un
patron dentro de un texto
O(N+M)
*/
# include <cstring>
# include <cstdio>
using namespace std;

int i, k, lp, lt;
int F[5005];

char Text[5005], Pattern[5005];

int main(){

    scanf("%s\n%s", Text+1, Pattern+1);
    lp = strlen(Pattern + 1);
    lt = strlen(Text + 1);

    for(i = 2; i <= lp; i++){
        while(k > 0 && Pattern[k + 1] != Pattern[i])
            k = F[k];
```

```
            if(Pattern[k + 1] == Pattern[i])
                  k++;

            F[i] = k;
      }

      k = 0;
      for(i = 1; i <= lt; i++){
            while(k > 0 && Pattern[k + 1] != Text[i])
                  k = F[k];

            if(Pattern[k + 1] == Text[i])k++;

            if(k == lp){
                  printf("%d ", i-lp+1);
                  k = F[k];
            }
      }

      return 0;
}
```

4.3. Cyclic Shift.

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

string min_cyclic_shift(string s){
      s += s;
      int n = (int) s.length ();
      int i = 0, ans = 0;
      while (i < n/2){
            ans = i;
            int j = i+1, k = i;

            while (j < n && s[k] <= s[j]){
                  if (s[k] < s[j]) k = i;
                  else ++k; ++j;
            }

            while (i <= k)
                  i += j - k;
      }

      return s.substr(ans, n / 2);
}

string S;
int n;
char A[505];

int main(){

      cin >> n;
      sprintf(A, "%d", n);
      S = min_cyclic_shift((string)A);
      cout << S;

      return 0;
}
```

4.4. Hashing.

```
/*****************************

   Hashing in strings based problems.

   This code compares substrings using two hashes (one
   uses 2^64 as a modulo, another 10^9 + 7)

   Based on problem C from here: http://codeforces.ru/gym/100133

*****************************/

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

const int MAXN = 105000;
const int mod = (int) 1e9 + 7;
const int p = 53;

string s;
int n, m;
```

```
long long h1[MAXN], h2[MAXN];
long long pp1[MAXN], pp2[MAXN];

long long getHash1(int l, int r) {
   l--; r--;
   long long h = h1[r];
   if (l > 0)
      h -= h1[l - 1];
   h *= pp1[n - 1 - r];
   return h;
}

long long getHash2(int l, int r) {
   l--; r--;
   long long h = h2[r];
   if (l > 0)
      h = (h - h2[l - 1] + mod) % mod;
   h = (h * pp2[n - 1 - r]) % mod;
   return h;
}

int main() {

   getline(cin, s);
   n = (int) s.length();

   pp1[0] = 1; pp2[0] = 1;
   for (int i = 1; i <= n; i++) {
      pp1[i] = pp1[i - 1] * p;
      pp2[i] = (pp2[i - 1] * p) % mod;
   }

   h1[0] = s[0] - 'a' + 1;
   h2[0] = (s[0] - 'a' + 1) % mod;
   for (int i = 1; i < n; i++) {
      h1[i] = h1[i - 1] + pp1[i] * (s[i] - 'a' + 1);
      h2[i] = (h2[i - 1] + pp2[i] * (s[i] - 'a' + 1)) % mod;
   }

   scanf("%d", &m);

   for (int i = 1; i <= m; i++) {
      int a, b, c, d;
      scanf("%d␣%d␣%d␣%d", &a, &b, &c, &d);
      if (getHash1(a, b) == getHash1(c, d) && getHash2(a, b) == getHash2(c, d))
         puts("Yes");
      else
         puts("No");
   }

   return 0;
}
```