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# **Template**

|  |
| --- |
| #include <bits/stdc++.h>  using namespace std;  #define inf 1000000000  #define unvisited -1  #define visited 1  #define eps 1e-9  #define pb push\_back  #define pi acos(-1.0)  typedef long long ll;  typedef vector<int> vi;  typedef pair<int,int> ii;  typedef vector<ii> vii;  int main() {    return 0;  } |

# **Segment Tree (+lazy propagation)**

|  |
| --- |
| class SegmentTree{  private:  vi st,lazy;  int n;  public:  void build(int p, int l, int r){  if(l==r){  st[p] = 0;  return;  }  int mid = (l+r)/2;  build(left(p),l,mid);  build(right(p),mid+1,r);  st[p] = st[left(p)] + st[right(p)];  }  SegmentTree(int n){  this->n = n;  st.assign(4\*n,0);  lazy.assign(4\*n,0);  build(1,1,n);  }  void update(int p, int l, int r, int i, int j,ll v){  if(lazy[p]!=0){  st[p]+=(r-l+1)\*lazy[p];  if(l!=r){ lazy[left(p)]+=lazy[p];  lazy[right(p)]+=lazy[p];  }  lazy[p] = 0;  }  if(i>r || j < l){return;}  if(l>=i && r<=j){  st[p] += (r-l+1)\*v;  if(l!=r){  lazy[left(p)]+=v;  lazy[right(p)]+=v;  }  return;  }  int mid = (l+r)/2;  update(left(p),l,mid,i,j,v);  update(right(p),mid+1,r,i,j,v);  st[p] = st[left(p)] + st[right(p)];  }  ll query(int p, int l, int r, int i, int j){  if(i>r || j<l){return 0;}  if(lazy[p]!=0){  st[p]+=(r-l+1)\*lazy[p];  if(l!=r){  lazy[left(p)]+=lazy[p];  lazy[right(p)]+=lazy[p];  }  lazy[p] = 0;  }  if(l>=i && r<=j){return st[p];}  int mid = (l+r)/2;  ll a = query(left(p),l,mid,i,j);  ll b = query(right(p),mid+1,r,i,j);  return (a+b);  }  }; |

# **UFDS**

|  |
| --- |
| class UnionFind{  private:  vi rank,p,setSize;  int numset,i;  public:  UnionFind(int n){  numset=n; setSize.assign(n,1);  rank.assign(n,0); p.assign(n,0);  for(i=0;i<n;i++){p[i]=i;}  }  int findSet(int i){return (p[i]==i) ? i : (p[i]=findSet(p[i]));}  bool isSameSet(int i, int j){return findSet(i)==findSet(j);}  void unionSet(int i, int j){  if(!isSameSet(i,j)){  numset--;  int x=findSet(i), y=findSet(j);  if(rank[x] > rank[y]){p[y]=x; setSize[x]+=setSize[y];}  else{  p[x]=y;  setSize[y]+=setSize[x];  if(rank[x]==rank[y]){rank[y]++;}  }  }  }  int numDisjointSet(){return numset;}  int sizeSetOf(int i){return setSize[findSet(i)];}  }; |

# **Bipartite Graph Check**

|  |
| --- |
| bool isBipartiteCheck (){  int n,e,i,j,a,b,v,vertex;  queue <int> q;  bool isBipartite;  while(scanf("%d",&n),n){  AdjList.assign(n,vi());  vi color(n,inf);  scanf("%d",&e);  for(i=0;i<e;i++){  scanf("%d %d",&a,&b);  AdjList[a].push\_back(b);  AdjList[b].push\_back(a);  }  q.push(0);color[0]=0;  isBipartite=true;  while(!q.empty() && isBipartite){  v = q.front(); q.pop();  for(i=0;i<(int)AdjList[v].size();i++){  vertex=AdjList[v][i];  if(color[vertex]==inf){  color[vertex]=1-color[v];  q.push(vertex);  }else if(color[vertex]==color[v]){  isBipartite=false;  }  }  }    return isBipartite;  } |

# **Finding a Cycle in a Graph**

|  |
| --- |
| void graphCheck(int u){  if(foundCycle){return;}  dfs\_num[u] = explored;  for(int i=0;i<AdjList[u].size();i++){  int v = AdjList[u][i];  if(dfs\_num[v] == unvisited){  graphCheck(v);  }  if(dfs\_num[v] == explored){  foundCycle = true;  }  }  dfs\_num[u] = visited;  } |

# **Finding Articulation Points and Bridges**

|  |
| --- |
| void articulationPointAndBridge(int u) {  dfs\_low[u]=dfs\_num[u]=dfsNumberCounter++;  for (int j = 0; j < AdjList[u].size(); j++) {  int v = AdjList[u][j];  if (dfs\_num[v] == DFS\_WHITE) { // a tree edge  dfs\_parent[v] = u;  if (u == dfsRoot) rootChildren++; // special case, count children of root  articulationPointAndBridge(v);  if (dfs\_low[v] >= dfs\_num[u]) // for articulation point  articulation\_vertex[u] = true; // store this information first  if (dfs\_low[v] > dfs\_num[u]) // for bridge  printf(" Edge (%d, %d) is a bridge\n", u, v);  dfs\_low[u] = min(dfs\_low[u], dfs\_low[v]; // update dfs\_low[u]  }  else if (v != dfs\_parent[u]) // a back edge and not direct cycle  dfs\_low[u] = min(dfs\_low[u], dfs\_num[v]); // update dfs\_low[u]  } } |

# **Finding SCC**

|  |
| --- |
| /\*\*\*\*\*\* Tarjan’s SCC \*\*\*\*\*\*\*/  vector< int > num, low, S, vis;  int cntr, numCC;  void tarjanSCC(int v) {  low[v] = num[v] = ++cntr;  vis[v] = 1;  S.push\_back(v);  for(auto u : adj[v]) {  if(num[u] == -1)  tarjanSCC(u);  if(vis[u])  low[v] = min(low[v], low[u]);  }  if(low[v] == num[v]) {  printf("SCC %d :", ++numCC);  while(1) {  int u = S.back(); S.pop\_back(); vis[u] = 0;  printf(" %d", u);  if(u == v)  break;  }  }  }  // In MAIN();  num.assign(n, -1);  low.assign(n, 0);  vis.assign(n, 0);  cntr = numCC = 0;  for(int i = 0; i<n; i++))  if(num[i] == -1)  tarjanSCC(i); |

# **Dijkstra**

|  |
| --- |
| vector <vii> AdjList;  vi dist;  int main(){  int V,E,s,u,v,w,i,j;    scanf("%d %d %d",&V,&E,&s);  AdjList.assign(V,vii());  dist.assign(V,inf);  for(i=0;i<E;i++){  scanf("%d %d %d",&u,&v,&w);  AdjList[u].push\_back(ii(v,w));  }    dist[s]=0;  priority\_queue <ii,vii,greater<ii> > pq; pq.push(ii(dist[s],s));//coba dimodif  while(!pq.empty()){  ii front=pq.top(); pq.pop();  int d=front.first,v1=front.second;  if(d > dist[v1]){continue;}//biar nanti otomatis ke pop sendiri -> lazy deletion  for(i=0;i<AdjList[v1].size();i++){  ii pair=AdjList[v1][i];  if(dist[pair.first] > pair.second+dist[v1]){  dist[pair.first]=pair.second+dist[v1];  pq.push(ii(dist[pair.first],pair.first));  }  }  } } |

# **Bellman Ford’s Algo (negative cycle check)**

|  |
| --- |
| dist.assign(n+1,inf); AdjList.assign(n+1,vii());  int w;  for(i=0;i<m;i++){scanf("%d %d %d",&a,&b,&w); AdjList[a].pb(ii(b,w));}  dist[u] = 0;  for(i=0;i<n-1;i++){  for(int k = 1;k<=n;k++){  for(j=0;j<AdjList[k].size();j++){  ii v = AdjList[k][j];  dist[v.first] = min(dist[v.first],dist[k] + v.second);  }  }  }  bool hasCycle = false;  for(int k = 1;k<=n;k++){  for(j=0;j<AdjList[k].size();j++){  ii v = AdjList[k][j];  if(dist[v.first] > dist[k]+v.second){hasCycle = true; break;}  }  if(hasCycle){break;}  }  if(hasCycle){printf("TIDAK\n");}  else{printf("BISA\n");} |

# **Floyd Warshall’s Algo (print path too)**

|  |
| --- |
| for(int k=1;k<=n;k++){  for(i=1;i<=n;i++){  for(j=1;j<=n;j++){  if(mat[i][j] > mat[i][k] + mat[k][j]){  mat[i][j] = mat[i][k] + mat[k][j];  p[i][j] = p[k][j];  }  }  }  }  //print path dr a ke b….  CatatPath(a,b);  //rekursif  void CatatPath(int i, int j){  if(i!=j){CatatPath(i,p[i][j]);}  //printf("yang dipush: %d\n",j);  ans.pb(j);  } |

# **Maxflow Edmond Karp**

|  |
| --- |
| #define maxn 102  int s,t,f,mf;  vi p;  int res[maxn][maxn];  vector<vi> AdjList;  void augment(int v, int minEdge){  if(v==s){f = minEdge; return;}  else if(p[v]!=-1){  augment(p[v],min(minEdge,res[p[v]][v]));  res[p[v]][v]-=f; res[v][p[v]]+=f;  }  }  int main() {  int n,i,j,a,b,w,test=1;  while(scanf("%d",&n),n){  AdjList.assign(n+1,vi());  printf("Network %d\n",test++);  memset(res,0,sizeof res);  int m;  scanf("%d %d %d",&s,&t,&m); s--; t--;  for(i=0;i<m;i++){  scanf("%d %d %d",&a,&b,&w); a--; b--;  res[a][b] +=w; res[b][a] += w;  AdjList[a].pb(b); AdjList[b].pb(a);  }  mf = 0;  while (1) { // now a true O(VE^2) Edmonds Karp's algorithm  f = 0;  bitset<maxn> vis; vis[s] = true; // we change vi dist to bitset!  queue<int> q; q.push(s);  p.assign(maxn, -1);  while (!q.empty()) {  int u = q.front(); q.pop();  if (u == t) break;  for (int j = 0; j < (int)AdjList[u].size(); j++) { // we use AdjList here!  int v = AdjList[u][j];  if (res[u][v] > 0 && !vis[v])  vis[v] = true, q.push(v), p[v] = u;  }  }  augment(t, inf);  if (f == 0) break;  mf += f;  }  printf("The bandwidth is %d.\n\n",mf);  AdjList.clear(); p.clear();  }    return 0;  } |

# **Eulerian Graph Check**

Jumlah node derajat ganjil = 0 -> eulerian tour

Klo jumlah ganjil ada 2->semua dikunjungin tp ga euler tour

Selain itu ga eulerian graph.

# **Printing Euler Tour**

|  |
| --- |
| list<int> cyc;  void EulerTour(list<int>::iterator i, int u){  for(int j=0;j<AdjList[u].size();j++){  ii v = AdjList[u][j];  if(v.second){  v.second = 0;  for(int k=0;k<AdjList[v.first].size();k++){  ii uu = AdjList[v.first][k];  if(uu.first == u && uu.second){  uu.second = 0;  break;  }  }  }  EulerTour(cyc.insert(i,u),v.first);  }  }  cyc.clear();  EulerTour(cyc.begin(),A);  for(list<int>::iterator it = cyc.begin();it!=cyc.begin();it++){  printf("%d\n",\*it);  } |

# **Binomial Coefficient**

|  |
| --- |
| C(n,0) = C(n,n) = 1;  C(n,k) = C(n-1,k-1) + c(n-1,k) //n>k>0 |

# **Catalan Numbers**

|  |
| --- |
| Cat(0) = 1;  Cat(m) = (2m\*(2m-1)/((m+1)\*m))\*cat(m-1); |

# **Factorization**

|  |
| --- |
| vi primefactor(ll n){  vi factors;  ll idx = 0, pf = prime[idx];  while(pf\*pf<=n){  while(n%pf==0){n/=pf; factors.push\_back(pf); }  pf = prime[++idx];  }  if(n!=1){factors.push\_back(n);}  return factors; } |

# **Sum of Divisors of N**

|  |
| --- |
| Ll sumDiv(ll n){  ll idx = 0, pf = prime[idx]; ans=1; while(pf\*pf<=n){  ll power = 0;  while(n%pf==0){n/=pf; power++;}  pf = prime[++idx];  ans\*=((ll)pow((double)pf,power+1.0)-1)/(pf-1);  pf = prime[++idx];  }  if(n!=1){ans\*=((ll)pow((double)n,2.0)-1)/(n-1);}  return ans;  } |

# **Euler Phi**

|  |
| --- |
| ll eulerPhi(ll n){  ll idx = 0, pf = prime[idx], ans = n;  while(pf\*pf<=n){  if(n%pf==0){ans-=ans/pf;}  while(n%pf==0){n/=pf;}  pf = prime[++idx];  }  if(n!=1){ans-=ans/n;}  return ans;  } |

# **Extended Euclid Algorithm**

|  |
| --- |
| long long x, y, d; // ax + by = d  void extendedEuclidean(long long a, long long b) {  if(b == 0) { x = 1; y = 0; d = a; return; }  extendedEuclidean(b, a % b);  long long xx, yy;  xx = y;  yy = x - (a/b)\*y;  x = xx; y = yy;  } |

# **Cycle Finding**

|  |
| --- |
| ll z,i,m;  ll f(ll x){  return ((z\*x)+i)%m;  }  ii floydCycleFinding(ll x0){  //cari k\*mu  ll tortoise = f(x0), hare = f(f(x0));  while(tortoise!=hare){tortoise = f(tortoise); hare = f(f(hare));}  //cari mu  int mu = 0; hare = x0;  while(tortoise!=hare){tortoise = f(tortoise); hare = f(f(hare)); mu++;}  //finding lambda  int lambda = 1;hare = f(tortoise);  while(tortoise!=hare){hare=f(hare); lambda++;}  return ii(mu,lambda); } |

# **KMP**

|  |
| --- |
| void kmpPreprocess() {  int i = 0, j = -1; b[0] = -1;  while(i<m) {  while(j >= 0 && pattern[i]!=pattern[j]) j = b[j];  i++; j++;  b[i] = j;  }  }  void kmpSearch() {  int i = 0, j = 0;  while(i<n) {  while(j >= 0 && text[i]!=pattern[j]) j = b[j];  i++; j++;  if(j == m) {  printf("pattern found in index %d\n",i-j);  j = b[j];  }  }  } |

# **Edit Distance**

|  |
| --- |
| int solve(string kata1,string kata2){  int panjang1 = kata1.length(),panjang2 = kata2.length();  int i,j;  //buat base case  for(i=0;i<=panjang1;i++){a[i][0] = i;}  for(j=0;j<=panjang2;j++){a[0][j] = j;}  for(i=1;i<=panjang1;i++){  for(j=1;j<=panjang2;j++){  if(kata1[i-1] == kata2[j-1]){a[i][j] = a[i-1][j-1];}  else{  a[i][j] = min(a[i-1][j],min(a[i][j-1],a[i-1][j-1])) + 1;  }  }  }  return a[panjang1][panjang2];  } |

# **Longest Palindrome**

|  |
| --- |
| int solve(int l, int r){  //if(l>r){return 0;}  if(l==r){return 1;}  if(l+1==r){  if(kata[l]==kata[r]){return 2;}  else{return 1;}  }  if(memo[l][r]!=-1){return memo[l][r];}  if(kata[l]==kata[r]){return memo[l][r] = 2 + solve(l+1,r-1);}  return memo[l][r] = max(solve(l,r-1),solve(l+1,r));  } |

# **LCS**

|  |
| --- |
| for i=0 to n {  a[i][0] = 0;//base case  }  for j=0 to m {  a[0][j] = 0;//base case  }  for i=1 to n {  for j=1 to m {  if(word1[i-1] = word2[j-1]) then  a[i][j] = a[i-1][j-1] + 1; //same characters  } else {  a[i][j] = max (a[i-1][j], a[i][j-1]);  //different characters  }  }  }  print a[n][m]; //printing the answer |

# **Template Geometri**

## **Points and Lines**

|  |
| --- |
| double degToRad(double a){return a\*pi/180.0;}  double radToDeg(double a){return a\*180.0/pi;}  struct point\_i{  int x,y;  point\_i(){x = 0; y=0;}  point\_i(int \_x, int \_y){x = \_x; y = \_y;}  };  struct point{  double x,y;  point(){x = y = 0.0;}  point(double \_x, double \_y): x(\_x), y(\_y){}  bool operator < (point other) const {  if(fabs(x-other.x)>eps){return x < other.x;}  return y<other.y;  }  bool operator == (point other){return ((fabs(x-other.x)<eps) && (fabs(y-other.y)<eps));}  };  double dist(point p1, point p2){return hypot(p1.x-p2.x,p1.y-p2.y);}  point rotate(point p, double theta){  double rad = degToRad(theta);  return point(p.x\*cos(rad) - p.y\*sin(rad), p.x\*sin(rad) + p.y\*cos(rad));  }  struct line{double a,b,c;};  void pointsToLine(point p1, point p2, line &l){  if(fabs(p1.x-p2.x) < eps){  l.a = 1.0; l.b = 0.0; l.c = -p1.x;  }else{  l.a = -(double)(p1.y-p2.y) / (p1.x-p2.x);  l.b = 1.0;  l.c = -(double)(l.a\*p1.x) - p1.y;  }  }  bool areParallel(line l1, line l2){return ((fabs(l1.a-l2.a)<eps) && (fabs(l1.b-l2.b)<eps));}  bool areSame(line l1, line l2){  if(areParallel(l1,l2)){return fabs(l1.c-l2.c)<eps;}  return false;  }  bool areIntersect(line l1, line l2, point &p){  if(areParallel(l1,l2)){return false;}  p.x = (l2.b\*l1.c - l1.b\*l2.c) / (l2.a\*l1.b - l1.a\*l2.b);  if(fabs(l1.b) > eps){p.y = -(l1.a\*p.x + l1.c);}  else{p.y = -(l2.a\*p.x + l2.c);}  return true;  }  struct vec{  double x,y;  vec(double \_x, double \_y): x(\_x), y(\_y){}  };  vec toVec(point a, point b){  return vec(b.x-a.x, b.y-a.y);  }  vec scale(vec v, double s){  return vec(v.x\*s,v.y\*s);  }  point translate(point p, vec v){//translate p sebanyak v  return point(p.x+v.x, p.y+v.y);  }  double dot(vec a, vec b){return (a.x\*b.x + a.y\*b.y);}  double norm\_sq(vec v){return (v.x\*v.x + v.y\*v.y);}  double distToLine(point p, point a, point b, point &c){  vec ap = toVec(a,p), ab = toVec(a,b);  double u = dot(ap,ab) / norm\_sq(ab);  c = translate(a,scale(ab,u));  return dist(p,c);  }  double distToLineSegment(point p, point a, point b, point &c){  vec ap = toVec(a,p), ab = toVec(a,b);  double u = dot(ap,ab) / norm\_sq(ab);  if(u<0.0){c = point(a.x,a.y); //closer to a  return dist(p,a);  }  if(u>1.0){  c = point(b.x,b.y);  return dist(p,b);  }  return distToLine(p,a,b,c);  }  double angle(point a, point o, point b){//return in rad  vec oa = toVec(o,a), ob = toVec(o,b);  return acos(dot(oa,ob) / sqrt(norm\_sq(oa) \* norm\_sq(ob)));  }  double cross(vec a, vec b){return a.x\*b.y - a.y\*b.x;}  bool ccw(point p, point q, point r){  return cross(toVec(p,q), toVec(p,r)) > 0;  }  bool collinear(point p, point q, point r){  return fabs(cross(toVec(p,q), toVec(p,r))) < eps;  } |

## **Circle**

|  |
| --- |
| int insideCirlce(point p, point center, double r){  double dx = p.x - center.x, dy = p.y-center.y;  double Euc = dx\*dx + dy\*dy, rSq = r\*r;  if(fabs(Euc-rSq)<eps){return 1;}//in border  if(Euc<rSq){return 0;}//inside  if(Euc>rSq){return 2;}//outside  }  bool circle2PtsRad(point p1, point p2, double r, point& c){  double d2 = (p1.x-p2.x)\*(p1.x-p2.x) + (p1.y-p2.y)\*(p1.y-p2.y);  double det = r\*r/d2 - 0.25;  if(det<0.0){return false;}  double h = sqrt(det);  c.x = (p1.x+p2.x)\*0.5 + (p1.y-p2.y)\*h;  c.y = (p1.y+p2.y)\*0.5 + (p2.x-p1.x)\*h;  return true;  } |

## **Triangle**

|  |
| --- |
| /\*Sudah ditambahkan library point\*/  /\*TAMBAHAN LIBRARY DARI TRIANGLE\*/  double perimeter(double ab, double bc, double ac){  return ab+bc+ac;  }  double perimeter(point a, point b, point c){  return perimeter(dist(a,b),dist(b,c),dist(a,c));  }  double area(double ab, double bc, double ac){  double s = perimeter(ab,bc,ac)\*0.5;  return sqrt(s)\*sqrt(s-ab)\*sqrt(s-bc)\*sqrt(s-ac);  }  double area(point a, point b, point c){  return area(dist(a,b), dist(b,c), dist(a,c));  }  double rInCircle(double ab, double bc, double ac){//panjang jari"lingkaran dalam  return(area(ab,bc,ac)/(0.5\*perimeter(ab,bc,ac)));  }  double rInCircle(point a, point b, point c){  return rInCircle(dist(a,b),dist(b,c),dist(a,c));  }  //cari titik tengah inscribed Circle dan radiusnya  int inCircle(point p1, point p2, point p3, point& ctr, double& r){//return 0..ga ada lingkaran dalam segitiga, otherwise return 1  r = rInCircle(p1,p2,p3);  if(fabs(r)<eps){return 0;}//3 point collinear  line l1,l2;  double ratio = dist(p1,p2)/dist(p1,p3);  point p = translate(p2,scale(toVec(p2,p3),ratio/(1+ratio)));  pointsToLine(p1,p,l1);  ratio = dist(p2,p1)/dist(p2,p3);  p = translate(p1,scale(toVec(p1,p3),ratio/(1+ratio)));  pointsToLine(p2,p,l2);  areIntersect(l1,l2,ctr);  return 1;  }  double rCircumCircle(double ab, double bc, double ac){  return ab\*bc\*ac / (4.0\*area(ab,bc,ac));  }  double rCircumCircle(point a, point b, point c){  return rCircumCircle(dist(a,b), dist(b,c), dist(a,c));  }  //cari titik tengah circumCircle dan radiusnya  int circumCircle(point p1, point p2, point p3, point &ctr, double &r){  double a = p2.x - p1.x, b = p2.y - p1.y;  double c = p3.x - p1.x, d = p3.y - p1.y;  double e = a \* (p1.x + p2.x) + b \* (p1.y + p2.y);  double f = c \* (p1.x + p3.x) + d \* (p1.y + p3.y);  double g = 2.0 \* (a \* (p3.y - p2.y) - b \* (p3.x - p2.x));  if (fabs(g) < eps) return 0;  ctr.x = (d\*e - b\*f) / g;  ctr.y = (a\*f - c\*e) / g;  r = dist(p1, ctr); // r = distance from center to 1 of the 3 points  return 1; }  // returns true if point d is inside the circumCircle defined by a,b,c  int inCircumCircle(point a, point b, point c, point d) {  return (a.x - d.x) \* (b.y - d.y) \* ((c.x - d.x) \* (c.x - d.x) + (c.y - d.y) \* (c.y - d.y)) +  (a.y - d.y) \* ((b.x - d.x) \* (b.x - d.x) + (b.y - d.y) \* (b.y - d.y)) \* (c.x - d.x) +  ((a.x - d.x) \* (a.x - d.x) + (a.y - d.y) \* (a.y - d.y)) \* (b.x - d.x) \* (c.y - d.y) -  ((a.x - d.x) \* (a.x - d.x) + (a.y - d.y) \* (a.y - d.y)) \* (b.y - d.y) \* (c.x - d.x) -  (a.y - d.y) \* (b.x - d.x) \* ((c.x - d.x) \* (c.x - d.x) + (c.y - d.y) \* (c.y - d.y)) -  (a.x - d.x) \* ((b.x - d.x) \* (b.x - d.x) + (b.y - d.y) \* (b.y - d.y)) \* (c.y - d.y) > 0 ? 1 : 0;  }  bool canFormTriangle(double a, double b, double c){  return (a+b>c) && (a+c>b) && (b+c>a);  } |

## **Polygon**

|  |
| --- |
| //sudah ditambahkan library point  double perimeter(const vector<point> &P){  double result = 0.0;  for(int i=0;i<P.size()-1;i++){  result+=dist(P[i],P[i+1]);  }  return result;  }  double area(const vector<point> &P){  double result = 0.0, x1,x2,y1,y2;  for(int i=0;i<P.size()-1;i++){  x1 = P[i].x; x2 = P[i+1].x;  y1 = P[i].y; y2 = P[i+1].y;  result+=(x1\*y2 - x2\*y1);  }  return fabs(result)/2.0;  }  bool isConvex(const vector<point> &P){  int sz = P.size();  if(sz <= 3){return false;}  bool isLeft = ccw(P[0],P[1],P[2]);  for(int i=1;i<sz-1;i++){  if(ccw(P[i],P[i+1],P[(i+2)==sz? 1:i+2]) != isLeft){return false;}  }  return true;  }  bool inPolygon(point pt, const vector<point> &P){  if(P.size()==0){return false;}  double sum = 0.0;  for(int i=0;i<P.size()-1;i++){  if(ccw(pt,P[i],P[i+1])){sum+=angle(P[i],pt,P[i+1]);}  else{sum-=angle(P[i],pt,P[i+1]);}  }  return fabs(fabs(sum)-2\*pi) <eps;  }  point pivot;  bool angleCmp(point a, point b){  if(collinear(pivot, a, b)){return dist(pivot,a) < dist(pivot,b);}  point d1,d2;  d1.x = a.x - pivot.x, d1.y = a.y - pivot.y;  d2.x = b.x - pivot.x, d2.y = b.y - pivot.y;  return (atan2(d1.y,d1.x) - atan2(d2.y,d2.x)) < 0;  }  vector<point> CH(vector<point> P) {  int i,j, n =P.size();  if(n<=3){  if(!(P[0]==P[n-1])){P.pb(P[0]);}  return P;  }  //find index so that P[idx] has lowest Y, if tie..the rightmost X  int idx = 0;  for(i=1;i<n;i++){  if(P[i].y < P[idx].y || (P[i].y==P[idx].y && P[i].x > P[idx].x)){  idx = i;  }  }  //swap routine  point temp = P[0]; P[0] = P[idx]; P[idx] = temp;  //sort  pivotf = P[0];  sort(++P.begin(),P.end(),angleCmp);  vector<point> S;  S.pb(P[n-1]); S.pb(P[0]); S.pb(P[1]);  i = 2;  while(i<n){  j = S.size()-1;  if(ccw(S[j-1],S[j],P[i])){S.pb(P[i++]);}  else{S.pop\_back();}  }  return S;  }  // line segment p-q intersect with line A-B.  point lineIntersectSeg(point p, point q, point A, point B) {  double a = B.y - A.y;  double b = A.x - B.x;  double c = B.x \* A.y - A.x \* B.y;  double u = fabs(a \* p.x + b \* p.y + c);  double v = fabs(a \* q.x + b \* q.y + c);  return point((p.x \* v + q.x \* u) / (u+v), (p.y \* v + q.y \* u) / (u+v)); }  // cuts polygon Q along the line formed by point a -> point b  // (note: the last point must be the same as the first point)  vector<point> cutPolygon(point a, point b, const vector<point> &Q) {  vector<point> P;  for (int i = 0; i < (int)Q.size(); i++) {  double left1 = cross(toVec(a, b), toVec(a, Q[i])), left2 = 0;  if (i != (int)Q.size()-1) left2 = cross(toVec(a, b), toVec(a, Q[i+1]));  if (left1 > -eps) P.push\_back(Q[i]); // Q[i] is on the left of ab  if (left1 \* left2 < -eps) // edge (Q[i], Q[i+1]) crosses line ab  P.push\_back(lineIntersectSeg(Q[i], Q[i+1], a, b));  }  if (!P.empty() && !(P.back() == P.front()))  P.push\_back(P.front()); // make P's first point = P's last point  return P; } |

# **LCA**

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| --- |
| int L[2\*maxn], H[2\*maxn], E[2\*maxn], idx;  void dfs(int cur, int parent, int depth) {  H[cur] = idx;  E[idx] = cur;  L[idx++] = depth;  for (int i = 0; i < AdjList[cur].size(); i++) {  int v = AdjList[cur][i];  if(v!=parent){  dfs(v, cur, depth+1);  E[idx] = cur; // backtrack to current node  L[idx++] = depth;  }    }  }  void buildRMQ() {  idx = 0;  memset(H, -1, sizeof H);  dfs(0, -1, 0); // we assume that the root is at index 0  }  //Code Segtree RMQ  int main() {  int n,i,j,a,b;  scanf("%d",&n);  AdjList.assign(n,vi());  for(i=0;i<n-1;i++){  scanf("%d %d",&a,&b); a--; b--;  AdjList[a].pb(b); AdjList[b].pb(a);  }    buildRMQ();    vi A;  for(i=0;i<2\*n;i++){A.pb(L[i]);}  SegmentTree s(A);  int q;  scanf("%d",&q);  while(q--){  scanf("%d %d",&a,&b);  a--; b--;  if(a==b){printf("TIDAK\n"); continue;}  int nilaiAcuan = a;  if(H[a] > H[b]){  swap(a,b);  nilaiAcuan = b;  }  int idx1 = H[a], idx2 = H[b];  int idx = s.rmq(idx1,idx2);  int ans = E[idx]; //hasil LCA  if(ans==nilaiAcuan){printf("TIDAK\n");}  else{printf("YA\n");}  }  return 0;  } |

# **Gcd-extended Algorithm**

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| --- |
| int gcd\_extended(int x,int y,int \*cx,int \*cy) //cx.x + cy.y = gcd(x,y)  {  if(y==0)  {  \*cx = 1;  \*cy = 0;  return x;  }  else  {  int dx,dy; //dx.y + dy.(x%y) = gcd(y,x%y) = gcd(x,y)  int result = gcd\_extended(y,x%y,&dx,&dy);    \*cx = dy;  \*cy = dx - dy\*(x/y);    return result;  }  }  /\* Explanation :  cx.x + cy.y = dx.y + dy.(x%y)  = dx.y + dy (x - (x/y)\*y)  = dx.y + dy.x - dy.y.(x/y)  = dy.x + (dx - dy(x/y)).y  cx.x = dy.x -> cx = dy  cy.y = (dx - dy(x/y)).y -> cy = dx - dy(x/y)  Base case (y=0) :  cx.x + cy.0 = gcd(x,0) = x  cx = 1, cy = 0  \*/  int main()  {  int a,b;  int c1,c2; //c1\*a + c2\*b = gcd(a,b)    printf("Enter 2 positive numbers : ");  scanf("%d %d",&a,&b);    if(a>b) //make a<=b, swap  {  a ^= b;  b ^= a;  a ^= b;  }    /\* Case : a^-1 (mod b) = .. \*/    if(gcd\_extended(a,b,&c1,&c2)!=1) printf("Modular multiplicative inverse does not exists.\n");  else  {  if(c1<0) c1 = b - (abs(c1)%b); //c1 may be negative, better make it positive  printf("Modular multiplicative inverse of %d (mod %d) is = %d.\n",a,b,c1);  }    /\* c1\*a + c2\*b = gcd(a,b) may be used to solve linear diophantine equation \*/    return 0;  } |

# **Rumus-rumus kombin**





















Dixon Identity:



where *a*, *b*, and *c* are non-negative integers





**Lucas’ Theorem :**

For non-negative integers *m* and *n* and a prime *p*, the following [congruence relation](https://en.wikipedia.org/wiki/Modular_arithmetic) holds:



where

m=m_kp^k+m_{k-1}p^{k-1}+\cdots +m_1p+m_0,

and

n=n_kp^k+n_{k-1}p^{k-1}+\cdots +n_1p+n_0

are the base *p* expansions of *m* and *n* respectively. This uses the convention that \tbinom{m}{n} = 0 if *m* < *n*.

Example : (combinatrics in small mod wheren mod < n && mod < k)

|  |
| --- |
| int comb[mod][mod];  int c(int n, int k) {  return n == 0? 1 : comb[n%mod][k%mod] \* c(n/mod, k/mod) % mod;  } |

**Faulhaber’s Formula**

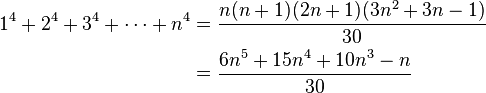


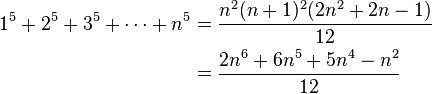
Examples:

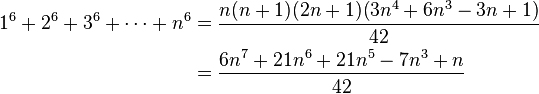
1 + 2 + 3 + \cdots + n = {n(n+1) \over 2} = {n^2 + n \over 2} (the [triangular numbers](https://en.wikipedia.org/wiki/Triangular_number))

1^2 + 2^2 + 3^2 + \cdots + n^2 = {n(n+1)(2n+1) \over 6} = {2n^3 + 3n^2 + n \over 6} (the [square pyramidal numbers](https://en.wikipedia.org/wiki/Square_pyramidal_number))

1^3 + 2^3 + 3^3 + \cdots + n^3 = \left({n(n+1) \over 2}\right)^2 = {n^4 + 2n^3 + n^2 \over 4} (the [squared triangular numbers](https://en.wikipedia.org/wiki/Squared_triangular_number))







# **Suffix Array + LCP**

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| --- |
| // suffix array  const int N = 1e5 + 5;  string s;  int sa[N], pos[N], lcp[N], tmp[N], gap, n;  bool cmp\_sa(int a, int b) {  if(pos[a] - pos[b])  return pos[a] < pos[b];  a += gap; b += gap;  return (a < n && b < n) ? pos[a] < pos[b] : a > b;  }  void build\_sa() {  n = s.size();  for(int i = 0; i<n; i++)  sa[i] = i, pos[i] = s[i];  for(gap = 1;; gap <<= 1) {  sort(sa, sa + n, cmp\_sa);  for(int i = 1; i<n; i++) tmp[i] = tmp[i-1] + cmp\_sa(sa[i-1], sa[i]);  for(int i = 0; i<n; i++) pos[sa[i]] = tmp[i];  if(tmp[n-1] == n-1) break;  }  }  void build\_lcp() {  for(int i = 0, k = 0; i<n; i++) if(pos[i] - n + 1) {  for(int j = sa[pos[i] + 1]; s[j + k] == s[i + k]; k++);  lcp[pos[i]] = k;  if(k) k--;  }  } |

# **FFT biasa & FFT versi modular arithmetic (perkalian polinom)**

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| --- |
| /\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* FFT dengan complex \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/  typedef complex<double> cd;  typedef vector< cd > vcd;  // asumsi ukuran as = 2^k, dengan k bilangan bulat positif  vcd fft(const vcd &as) {  int n = (int)as.size();  int k = 0;  while((1<<k) < n) k++;  vector< int > r(n);  r[0] = 0;  int h = -1;  for(int i = 1; i<n; i++) {  if((i & (i-1)) == 0)  h++;  r[i] = r[i ^ (1 << h)];  r[i] |= (1<<(k-h-1));  }  vcd root(n);  for(int i = 0; i<n; i++) {  double ang = 2.0\*M\_PI\*i/n;  root[i] = cd(cos(ang), sin(ang));  }  vcd cur(n);  for(int i = 0; i<n; i++)  cur[i] = as[r[i]];  for(int len = 1; len < n; len <<= 1 ) {  vcd ncur(n);  int step = n/(len << 1);  for(int pdest = 0; pdest <n;) {  for(int i = 0; i<len; i++) {  cd val = root[i\*step]\*cur[pdest + len];  ncur[pdest] = cur[pdest] + val;  ncur[pdest + len] = cur[pdest] - val;  pdest++;  }  pdest += len;  }  cur.swap(ncur);  }  return cur;  }  vcd inv\_fft(const vcd& fa) {  vcd res = fft(fa);  for(int i = 0; i<nn; i++) {  res[i] /= nn;  }  reverse(res.begin() + 1, res.end());  return res;  }  /\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* FFT dengan Modular Aritmetic \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/  const int mod = 7340033;  const int root = 5;  const int root\_1 = 4404020;  const int root\_pw = 1<<20;    void fft (vector<int> & a, bool invert) {  int n = (int) a.size();    for (int i=1, j=0; i<n; ++i) {  int bit = n >> 1;  for (; j>=bit; bit>>=1)  j -= bit;  j += bit;  if (i < j)  swap (a[i], a[j]);  }    for (int len=2; len<=n; len<<=1) {  int wlen = invert ? root\_1 : root;  for (int i=len; i<root\_pw; i<<=1)  wlen = int (wlen \* 1ll \* wlen % mod);  for (int i=0; i<n; i+=len) {  int w = 1;  for (int j=0; j<len/2; ++j) {  int u = a[i+j], v = int (a[i+j+len/2] \* 1ll \* w % mod);  a[i+j] = u+v < mod ? u+v : u+v-mod;  a[i+j+len/2] = u-v >= 0 ? u-v : u-v+mod;  w = int (w \* 1ll \* wlen % mod);  }  }  }  if (invert) {  int nrev = reverse (n, mod);  for (int i=0; i<n; ++i)  a[i] = int (a[i] \* 1ll \* nrev % mod);  } |

Trie

|  |
| --- |
| const int ALPHABET\_SIZE = 26;  struct TrieNode {  struct TrieNode \*children[ALPHABET\_SIZE];  int maks;  };  struct TrieNode \*getNode() {  struct TrieNode \*pNode = new TrieNode;  for(int i=0;i<ALPHABET\_SIZE;i++){  pNode->children[i] = NULL;  pNode->maks = -1;  }  return pNode;  }  void insert(struct TrieNode \*root, string key, int nilai) {  struct TrieNode \*pCrawl = root;  for(int i=0;i<key.length();i++){  int idx = key[i] - 'a';  if(!pCrawl->children[idx]){  pCrawl->children[idx] = getNode();  }  pCrawl = pCrawl->children[idx];  pCrawl->maks = max(pCrawl->maks, nilai);  }  }  int getMax(struct TrieNode \*root, string kata) {  struct TrieNode \*pCrawl = root;  for(int i=0;i<kata.length();i++){  int idx = kata[i] - 'a';  if(!pCrawl->children[idx]){  return -1;  }  pCrawl = pCrawl->children[idx];  }  return pCrawl->maks;  }  int main(){  int n,i,j,q;  scanf("%d %d",&n,&q);  struct TrieNode \*root = getNode();    for(i=0;i<n;i++){  string kata;  int nilai;  cin>>kata;  scanf("%d",&nilai);  insert(root, kata, nilai);  }  while(q--){  string kata;  cin>>kata;  int ans = getMax(root, kata);  printf("%d\n",ans);  }  return 0;  }; |

# **Convex hull (Graham’s Scan & Andrew’s Monotone Chain)**

|  |
| --- |
| typedef pair<long long,long long> point;  #define x first  #define y second  // (p-q) x (r-q)  long long cross(point p, point q, point r) {  return (p.x - q.x) \* (r.y - q.y) - (p.y - q.y) \* (r.x - q.x);  }  bool collinear(point a, point o, point b) {  return cross(a, o, b) == 0;  }  // true if point r is on the left side of line pq  bool ccw(point p, point q, point r) {  return cross(p, q, r) > 0;  }  point pivot;  long long dist2(point a, point b) {  return (a.x - b.x) \* (a.x - b.x) + (a.y - b.y) \* (a.y - b.y);  }  bool angle\_cmp(point a, point b) {  if(collinear(pivot, a, b)) {  return dist2(a, pivot) < dist2(b, pivot);  }  return ccw(pivot, a, b);  }  bool cmp(point a, point b) {  return a.y < b.y || (a.y == b.y && a.x < b.x);  }  // P tidak siklik, P[0] tidak mengulang di P.back()  // return convex hull siklik, P[0] mengulang di P.back()  vector<point> ConvexHull(vector<point> P) {  int i, j, n = (int) P.size();  if(n < 3)  return P;  int PO = 0;  for(i = 1; i < n; i++) {  if(cmp(P[P0], P[P[i]])) {  PO = i;  }  }  swap(P[0], P[PO]);  pivot = P[0];  if(collinear(P.back(), P[0], P[1])) {  vector< point > S;  S.push\_back(P[0]);  S.push\_back(P.back());  return S;  }  sort(++P.begin(), P.end(), angle\_cmp);  int k = P.size() - 1;  while(k && collinear(P[0], P[k-1], P[k])) k--;  reverse(P.begin() + k, P.end());  vector<point> S;  S.push\_back(P[n-1]);  S.push\_back(P[0]);  S.push\_back(P[1]);  i = 2;  while(i < n) {  j = (int) S.size() - 1;  if(ccw(S[j-1], S[j], P[i])) S.push\_back(P[i++]);  else S.pop\_back();  }  S.pop\_back();  return S;  }  int main(void)  {  int n;  scanf("%d", &n);  vector<point> p;  for(int i = 0; i < n; i++) {  int a, b;  scanf("%d %d", &a, &b);  p.push\_back(point(a, b));  }  vector<point> ch = ConvexHull(p);  cout << ch.size() << endl;  for(auto it : ch) {  printf("%I64d %I64d\n", it.x, it.y);  }  return 0; |