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## 1 Sync

### 1.1 Sync

```
1 int main(){
2     std::ios::sync_with_stdio(false);
3     // 開始寫程式
4 }
```

## 2 Data Structure

### 2.1 Binary Search

```
1 int binary_search(int arr[maxn], int lef, int rig,
2     int target){
3     if(lef > rig) return 0x3f3f3f3f;
4     int mid = (lef + rig) >> 1;
5     if(arr[mid] == target) return mid;
6     else if(arr[mid] > target){
7         return binary_search(arr, lef, mid - 1,
8             target);
9     }
10    else{
11        return binary_search(arr, mid + 1, rig,
12            target);
13    }
14 }
```

### 2.2 BIT

```
1 /* BIT Binary Index Tree */
2 #define lowbit(k) (k & -k)
3 void add(vector<int> &tr, int id, int val) {
4     for (; id <= n; id += lowbit(id)) {
5         tr[id] += val;
6     }
7 }
8 int sum(vector<int> &tr, int id) {
9     int ret = 0;
10    for (; id >= 1; id -= lowbit(id)) {
11        ret += tr[id];
12    }
13    return ret;
14 }
```

### 2.3 BWT

```
1 /* BWT 資料轉換演算法 */
2 void BWT(){
3     for(int i = 0; i < n; ++i){
4         if(back[i] == 0)
5             mini[zero++] = i;
6     }
7     for(int i = 0; i < n; ++i)
8         if(back[i] == 1)
```

```

8         mini[zero++] = i;
9     int ptr = mini[0];
10    for(int i = 0; i < n; ++i){
11        cout << back[ptr] << " ";
12        ptr = mini[ptr];
13    }
14    cout << endl;
15 }

```

## 3 Divide and Conquer

### 3.1 count inversions

```

1  /*逆序數對*/
2  int arr[maxn], buf[maxn];
3  int count_inversions(int lef, int rig){
4      if(rig - lef <= 1) return 0;
5      int mid = (lef + rig)/2;
6      int ans = count_inversions(lef, mid) +
7                count_inversions(mid, rig);
8      int i = lef, j = mid, k = lef;
9      while(i < mid || j < rig){
10         if(i >= mid) buf[k] = arr[j++];
11         else if(j >= rig) buf[k] = arr[i++];
12         else{
13             if(arr[i] <= arr[j]) buf[k] = arr[i++];
14             else{
15                 buf[k] = arr[j++];
16                 ans += mid - i;
17             }
18             k++;
19         }
20     }
21     for(int k = lef; k < rig; ++k) arr[k] = buf[k];
22     return ans;
23 }

```

## 4 DP

### 4.1 Doubling

```

1  /* 倍增 */
2  int LOG = sqrt(N); // 2^LOG >= N
3  vector<int> arr(N);
4  vector<vector<int>> dp(N, vector<int>(LOG));
5  for(int i = 0; i < N; ++i) cin >> arr[i];
6  int L, Q, a, b;
7  cin >> L >> Q;
8  for(int i = 0; i < N; ++i){
9      dp[i][0] = lower_bound(arr.begin(), arr.end(),
10                             arr[i] + L) - arr.begin();
11      if(dp[i][0] == N || arr[i] + L < arr[dp[i][0]])
12          dp[i][0] = -1;
13  }
14  for(int i = 1; i < LOG; ++i)
15      for(int j = 0; j < N; ++j)
16          dp[j][i] = dp[dp[j][i-1]][i-1];
17  for(int i = 0; i < Q; ++i){
18      cin >> a >> b;
19      a--; // 要減減是因為arr的index從0開始但題目從1開始
20      b--;
21      if(a > b) swap(a, b);
22      int ans = 0;
23      for(int i = LOG - 1; i >= 0; --i){ // 從後往前推
24          if(dp[a][i] < b){
25              ans += (1 << i);
26              a = dp[a][i];
27          }
28      }
29      cout << ans + 1 << endl;
30  }

```

## 4.2 LCS

```

1  /* Longest Common Subsequence */
2  int LCS(string s1, string s2) {
3      int n1 = s1.size(), n2 = s2.size();
4      int dp[n1+1][n2+1] = {0};
5      // dp[i][j] = s1的前i個字元和s2的前j個字元
6      for (int i = 1; i <= n1; i++) {
7          for (int j = 1; j <= n2; j++) {
8              if (s1[i-1] == s2[j-1]) {
9                  dp[i][j] = dp[i-1][j-1] + 1;
10             } else {
11                 dp[i][j] = max(dp[i-1][j], dp[i][j-1]);
12             }
13         }
14     }
15     return dp[n1][n2];
16 }

```

## 4.3 LIS

```

1  /* Longest Increasing Subsequence */
2  int LIS(vector<int> &a) {
3      vector<int> s;
4      for (int i = 0; i < a.size(); i++) {
5          if (s.empty() || s.back() < a[i]) {
6              s.push_back(a[i]);
7          } else {
8              *lower_bound(s.begin(), s.end(), a[i],
9                           [](int x, int y) {return x < y;}) = a[i];
10         }
11     }
12     return s.size();
13 }

```

## 4.4 LIS 2

```

1  int LIS(vector<int> &a){
2      int len[a.size()];
3      for(int i = 0; i < a.size(); ++i) len[i] = 1;
4      int maxi = -1;
5      for(int i = 0; i < a.size(); ++i)
6          for(int j = i + 1; j < a.size(); ++j)
7              if(a[i] <= a[j]) len[j] = max(len[j],
8                                              len[i] + 1);
9
10     for(int i = 0; i < a.size(); ++i)
11         maxi = max(maxi, len[i]);
12     return maxi;
13 }

```

## 5 Enumerate

### 5.1 Halfcut Enumerate

```

1  /* 折半枚舉 */
2  void dfs(set<long long int> &s, int depth, int T,
3           long long int sum){
4      if(depth >= T){
5          s.insert(sum);
6          return;
7      }
8      dfs(s, depth + 1, T, sum); // 取或不取的概念
9      dfs(s, depth + 1, T, sum + A[depth]);
10 }
11 int main(){
12     int N, T;
13     set<long long int> s1, s2;
14     cin >> N >> T;

```

```

14   for(int i = 0; i < N; ++i) cin >> A[i];
15   dfs(s1, 0, N/2, 0); // 折半枚舉
16   dfs(s2, N/2, N, 0);
17   long long int ans = 0;
18   // 題目:枚舉集合 Sx 的數字 Sxi, 找出 Sy
    集合內小於等於 T-Sxi 中最大的數 Syj
19   for(auto &x : s1){
20       auto it = s2.upper_bound(T - x);
21       long long int y = *(--it);
22       if(x + y <= T) ans = max(ans, x + y);
23   }
24   cout << ans << endl;
25 }

```

```

20   Item now = pq.top();
21   pq.pop();
22   if(now.dis > dis[now.u]){
23       continue;
24   }
25   // 鬆弛更新, 把與 now.u 相連的點都跑一遍
26   for(Edge e : G[now.u]){
27       if(dis[e.v] > now.dis + e.w){
28           dis[e.v] = now.dis + e.w;
29           pq.push({e.v, dis[e.v]});
30       }
31   }
32 }
33 }

```

## 6 Graph

### 6.1 SPFA

```

1 bool SPFA(int s){
2     // 記得初始化這些陣列
3     int cnt[1000+5], dis[1000+5];
4     bool inqueue[1000+5];
5     queue<int> q;
6
7     q.push(s);
8     dis[s] = 0;
9     inqueue[s] = true;
10    cnt[s] = 1;
11    while(!q.empty()){
12        int now = q.front();
13        q.pop();
14        inqueue[now] = false;
15
16        for(auto &e : G[now]){
17            if(dis[e.t] > dis[now] + e.w){
18                dis[e.t] = dis[now] + e.w;
19                if(!inqueue[e.t]){
20                    cnt[e.t]++;
21                    if(cnt[e.t] > m){
22                        return false;
23                    }
24                    inqueue[e.t] = true;
25                    q.push(e.t);
26                }
27            }
28        }
29    }
30    return true;
31 }

```

### 6.2 Dijkstra

```

1 /* Dijkstra 最短路徑 */
2 struct Item{
3     int u, dis;
4     // 取路徑最短
5     bool operator < (const Item &other) const{
6         return dis > other.dis;
7     }
8 };
9 int dis[maxn];
10 vector<Edge> G[maxn];
11 void dijkstra(int s){
12     for(int i = 0; i <= n; i++){
13         dis[i] = inf;
14     }
15     dis[s] = 0;
16     priority_queue<Item> pq;
17     pq.push({s, 0});
18     while(!pq.empty()){
19         // 取路徑最短的點

```

### 6.3 Floyd Warshall

```

1 void floyd_warshall(){
2     for(int i = 0; i < n; i++){
3         for(int j = 0; j < n; j++){
4             G[i][j] = INF;
5         }
6         G[i][i] = 0;
7     }
8     for (int k = 0; k < n; k++){ // 嘗試每一個中繼點
9         for (int i = 0; i < n; i++){ // 計算每一個 i 點與每一個 j 點
10            for (int j = 0; j < n; j++){
11                G[i][j] = min(G[i][j], G[i][k] + G[k][j]);
12            }
13        }
14    }
15 }

```

### 6.4 Disjoint set Kruskal

```

1 struct Edge{
2     int u, v, w;
3     // 用權重排序 由大到小
4     bool operator < (const Edge &other) const{
5         return w > other.w;
6     }
7 }edge[maxn];
8 // disjoint set
9 int find(int x){
10    if(parent[x] < 0){
11        return x;
12    }
13    else{
14        return parent[x] = find(parent[x]);
15    }
16 }
17 void unite(int a, int b){
18     a = find(a);
19     b = find(b);
20     if(a != b){
21         if(parent[a] < parent[b]){
22             parent[a] += parent[b];
23             parent[b] = a;
24         }
25         else{
26             parent[b] += parent[a];
27             parent[a] = b;
28         }
29     }
30 }
31 void kruskal(){
32     memset(parent, -1, sizeof(parent));
33     sort(edge, edge + m);
34     int i, j;
35     for(i = 0, j = 0; i < n - 1 && j < m; i++){

```

```

36 // 如果 u 和 v 的祖先相同, 則 j++
    // (祖先相同代表會產生環 所以不要)
37 while(find(edge[j].u) == find(edge[j].v)) j++;
38 // 若部會產生環 則讓兩點之間產生橋
    // (連接兩顆子生成樹)
39 unite(edge[j].u, edge[j].v);
40 j++;
41 }
42 }

```

## 6.5 Disjoint set Kruskal 2

```

1 struct Edge{
2     int u, v;
3     double w;
4     bool operator < (const Edge &rhs) const{
5         return w < rhs.w;
6     }
7 }edge[maxn * maxn];
8 vector<Edge> G[maxn]; // 紀錄有哪些邊在 MST 上
9 int parent[maxn];
10 // disjoint set
11 int find(int x){
12     return x == parent[x] ? x : parent[x] =
        find(parent[x]);
13 }
14 bool unite(int a, int b){
15     int x = find(a);
16     int y = find(b);
17     if(x == y) return false;
18     parent[x] = y;
19     return true;
20 }
21 double kruskal(){
22     m = 0; // m: 邊的數量
23     for(int i = 0; i < n; ++i)
24         for(int j = i + 1; j < n; ++j)
25             edge[m++] = (Edge){i, j, dist(i, j)};
26     sort(edge, edge + m);
27     for(int i = 0; i < n; ++i){
28         parent[i] = i;
29         G[i].clear();
30     }
31     double total = 0.0;
32     int edge_cnt = 0;
33     for(int i = 0; i < m; ++i){
34         int u = edge[i].u, v = edge[i].v;
35         double cnt = edge[i].w;
36         if(unite(u, v)){
37             G[u].push_back((Edge){u, v, cnt});
38             G[v].push_back((Edge){v, u, cnt});
39             total += cnt;
40             if(++edge_cnt == n-1) break;
41         }
42     }
43     return total;
44 }

```

## 6.6 Bipatirate

```

1 /* 二分圖 */
2 const int maxn = 300 + 5;
3 int n, color[maxn];
4 vector<vector<int>> v(maxn);
5 bool dfs(int s){
6     for(auto it : v[s]){
7         if(color[it] == -1){
8             color[it] = 3 - color[s];
9             if(!dfs(it)){
10                 return false;
11             }
12         }
13     }
14     if(color[s] == color[it]){

```

```

14         return false;
15     }
16 }
17 return true;
18 }
19 void isBipatirate(){
20     bool flag = true;
21     for(int i = 1; i <= n; ++i){
22         if(color[i] == -1){
23             color[i] = 1;
24             flag &= dfs(i);
25         }
26     }
27     if(flag){
28         cout << "YES" << endl;
29     }
30     else{
31         cout << "NO" << endl;
32     }
33 }
34 int main(){
35     while(cin >> n && n){
36         for(int i = 1; i <= n; ++i) v[i].clear();
37         memset(color, -1, sizeof(color));
38         int a, b;
39         while(cin >> a >> b && (a || b)){
40             v[a].emplace_back(b);
41             v[b].emplace_back(a);
42         }
43         isBipatirate();
44     }
45 }

```

## 6.7 Hungarian algorithm

```

1 /* 匈牙利演算法 */
2 const int maxn = 500+5;
3 int t, N, bn, gn, match[maxn];
4 bool visited[maxn];
5 vector<vector<int>> G(maxn);
6 struct People{
7     int h;
8     string music, sport;
9     People(){}
10     People(int h, string music, string sport){
11         this->h = h;
12         this->music = music;
13         this->sport = sport;
14     }
15 }lef[maxn], rig[maxn];
16 bool check(People boy, People girl){
17     if(abs(boy.h - girl.h) <= 40 && boy.music ==
        girl.music && boy.sport != girl.sport) return
        true;
18     return false;
19 }
20 bool dfs(int s){
21     for(int i = 0; i < G[s].size(); ++i){
22         int v = G[s][i];
23         if(visited[v]) continue;
24         visited[v] = true;
25         if(match[v] == -1 || dfs(match[v])){
26             match[v] = s;
27             return true;
28         }
29     }
30     return false;
31 }
32 int Hungarian(){
33     int cnt = 0;
34     memset(match, -1, sizeof(match));
35     for(int i = 0; i < bn; ++i){
36         memset(visited, false, sizeof(visited));
37         if(dfs(i)) cnt++;
38     }
39     return cnt;

```

```

40 }
41 int main(){
42     cin >> t;
43     while(t--){
44         cin >> N;
45         bn = 0, gn = 0;
46         for(int i = 0; i <= N; ++i) G[i].clear();
47         int h;
48         string sex, music, sport;
49         for(int i = 0; i < N; ++i){
50             cin >> h >> sex >> music >> sport;
51             if(sex == "M") lef[bn++] = People(h,
52                 music, sport);
53             else rig[gn++] = People(h, music, sport);
54         }
55         for(int i = 0; i < bn; ++i){
56             for(int j = 0; j < gn; ++j)
57                 if(check(lef[i], rig[j]))
58                     G[i].emplace_back(j);
59         }
60     }
61     cout << N - Hungarian() << endl;
62 }

```

## 6.8 LCA

```

1  /* 最低共同祖先 */
2  // 此 node 下有機顆 node
3  int dfs(int node, int dep){
4      depth[node] = dep + 1;
5      if(G[node].empty()){
6          siz[node] = 1;
7          return 1;
8      }
9      int total = 1;
10     for(auto i : G[node])
11         total += dfs(i.v, dep + 1);
12     siz[node] = total;
13     return siz[node];
14 }
15 // 找出每個節點的 2^i 倍祖先
16 // 2^20 = 1e6 > 200000
17 void find_parent(){
18     for(int i = 1; i < 20; i++){
19         for (int j = 0; j < N; j++){
20             parent[j][i] =
21                 parent[parent[j][i-1]][i-1];
22         }
23     }
24     // 求兩點的 LCA (利用倍增法)
25     int LCA(int a, int b){
26         if (depth[b] < depth[a]) swap(a, b);
27         if (depth[a] != depth[b]){
28             int dif = depth[b] - depth[a];
29             for (int i = 0; i < 20; i++){
30                 if (dif & 1) b = parent[b][i];
31                 dif >>= 1;
32             }
33         }
34         if (a == b) return a;
35         for (int i = 19; i >= 0; i--){
36             if (parent[a][i] != parent[b][i]){
37                 a = parent[a][i];
38                 b = parent[b][i];
39             }
40         }
41         return parent[a][0];
42     }
43 }

```

## 6.9 Trie

```

1  /* Trie 字典樹 */
2  struct Tire{
3      int path;

```

```

4      map<string, int> G[maxn];
5      void init(){
6          path = 1;
7          G[0].clear();
8      }
9      void insert(string str){
10         int u = 0;
11         string word = "";
12         for(int i = 0; i < str.size(); ++i){
13             if(str[i] == '\\'){
14                 if(!G[u].count(word)){
15                     G[path].clear();
16                     G[u][word] = path++;
17                 }
18                 u = G[u][word];
19                 word = "";
20             }
21             else word += str[i];
22         }
23     }
24     void put(int u, int space){
25         for(auto i = G[u].begin(); i != G[u].end();
26             ++i){
27             for(int j = 0; j < space; ++j){
28                 cout << " ";
29             }
30             cout << i->first << endl;
31             put(i->second, space + 1);
32         }
33     }
34 }
35 }
36 }
37 }
38 }
39 }
40 }
41 }
42 }
43 }
44 }
45 }
46 }
47 }
48 }
49 }
50 }
51 }
52 }
53 }
54 }
55 }
56 }
57 }
58 }
59 }
60 }

```

## 7 Math

### 7.1 Hash

```

1  /* 建議搭配 Other - Stammering Aliens 食用 */
2  #define ull unsigned long long int
3  const int maxn = 400005;
4  const ull seed = 131;
5  ull pw[maxn], hhash[maxn], hhash2[maxn];
6  char str[maxn];
7  void init(){
8      hhash[0] = 0;
9      for(int i = len-1; i >= 0; --i)
10         hhash[i] = (hhash[i+1] * seed + str[i]);
11 }

```

## 8 Other

### 8.1 Ants Colony

```

1  /* LCA 最低共同祖先 */
2  const int maxn = 1e5 + 5;
3  struct Edge{
4      int v;
5      int w;
6  };
7  int N;
8  vector<Edge> G[maxn];
9  int parent[maxn][20+5];
10 int depth[maxn], siz[maxn];
11 // 此 node 下有機顆 node
12 int dfs(int node, int dep){
13     depth[node] = dep + 1;
14     if(G[node].empty()){
15         siz[node] = 1;
16         return 1;
17     }
18     int total = 1;
19     for(auto i : G[node])

```

```

20     total += dfs(i.v, dep + 1);
21     siz[node] = total;
22     return siz[node];
23 }
24 // 找出每個節點的 2^i 倍祖先
25 // 2^20 = 1e6 > 200000
26 void find_parent(){
27     for(int i = 1; i < 20; i++){
28         for (int j = 0; j < N; j++){
29             parent[j][i] =
                parent[parent[j][i-1]][i-1];
30     }
31 // 求兩點的LCA (利用倍增法)
32 int LCA(int a, int b){
33     if (depth[b] < depth[a]) swap(a, b);
34     if (depth[a] != depth[b]){
35         int dif = depth[b] - depth[a];
36         for (int i = 0; i < 20; i++){
37             if (dif & 1) b = parent[b][i];
38             dif >>= 1;
39         }
40     }
41     if (a == b) return a;
42     for (int i = 19; i >= 0; i--){
43         if (parent[a][i] != parent[b][i]){
44             a = parent[a][i];
45             b = parent[b][i];
46         }
47     }
48     return parent[a][0];
49 }
50 long long int dist[maxn];
51 // 從 0 開始到每個點的距離
52 void distance(){
53     for (int u = 0; u < N; ++u){
54         for(int i = 0; i < G[u].size(); ++i){
55             dist[G[u][i].v] = dist[u] + G[u][i].w;
56         }
57     }
58 int main(){
59     while(cin >> N && N){
60         memset(dist, 0, sizeof(dist));
61         memset(parent, 0, sizeof(parent));
62         memset(depth, 0, sizeof(depth));
63         memset(siz, 0, sizeof(siz));
64         for(int i = 0; i <= N; ++i){
65             G[i].clear();
66         }
67         for(int i = 1; i < N; ++i){
68             int u, w;
69             cin >> u >> w;
70             G[u].push_back({i, w});
71             parent[i][0] = u;
72         }
73         find_parent();
74         dfs(0, 0);
75         distance();
76         int s; cin >> s;
77         bool space = false;
78         for(int i = 0; i < s; ++i){
79             int a, b;
80             cin >> a >> b;
81             int lca = LCA(a, b);
82             if(space) cout << " ";
83             space = true;
84             cout << (dist[a] + dist[b]) - (dist[lca]
                * 2);
85         }
86         cout << endl;
87     }

```

## 8.2 Binary codes

```

1 /* BWT 資料轉換演算法 */
2 void BWT(){

```

```

3     for(int i = 0; i < n; ++i){
4         if(back[i] == 0){
5             mini[zero++] = i;
6         }
7         for(int i = 0; i < n; ++i){
8             if(back[i] == 1){
9                 mini[zero++] = i;
10            }
11            int ptr = mini[0];
12            for(int i = 0; i < n; ++i){
13                cout << back[ptr] << " ";
14                ptr = mini[ptr];
15            }
16            cout << endl;
17        }
18    }
19 int main(){
20     cin >> n;
21     for(int i = 0; i < n; ++i){
22         cin >> back[i];
23     }
24     zero = 0;
25     BWT();
26 }

```

## 8.3 Fire Fire Fire

```

1 /* dfs
2 只要我有一個小孩不是防火牆，我就必須是防火牆 */
3 const int maxn = 1000+5;
4 int cnt = 0;
5 vector<int> G[maxn];
6 bool exi[maxn], visited[maxn];
7 void dfs(int node, int parent){
8     if(G[node].size() == 1 && G[node][0] == parent)
9         return;
10    for(int i = 0; i < G[node].size(); ++i){
11        int now = G[node][i];
12        if(visited[now]) continue;
13        visited[now] = true;
14        dfs(G[node][i], node);
15    }
16    bool flag = false;
17    for(int j = 0; j < G[node].size(); ++j){
18        if(exi[G[node][j]] != true && G[node][j] !=
19            parent){
20            flag = true;
21            break;
22        }
23    }
24    if(flag && exi[node] != true){
25        exi[node] = true;
26        cnt++;
27    }
28    return;
29 }
30 int main(){
31     int n;
32     while(cin >> n && n){
33         for(int i = 1; i <= n; ++i) G[i].clear();
34         memset(exi, false, sizeof(exi));
35         memset(visited, false, sizeof(visited));
36         for(int i = 1; i <= n; ++i){
37             int siz; cin >> siz;
38             for(int j = 0; j < siz; ++j){
39                 int num; cin >> num;
40                 G[i].emplace_back(num);
41             }
42         }
43         cnt = 0;
44         dfs(1, 1);
45         if(n == 1) cnt++;
46         cout << cnt << endl;
47     }
48 }

```

## 8.4 Disk Tree

```

1  /* Trie 字典樹 */
2  const int maxn = 50000+5;
3  struct Tire{
4      int path;
5      map<string, int> G[maxn];
6      void init(){
7          path = 1;
8          G[0].clear();
9      }
10     void insert(string str){
11         int u = 0;
12         string word = "";
13         for(int i = 0; i < str.size(); ++i){
14             if(str[i] == '\\'){
15                 if(!G[u].count(word)){
16                     G[path].clear();
17                     G[u][word] = path++;
18                 }
19                 u = G[u][word];
20                 word = "";
21             }
22             else word += str[i];
23         }
24     }
25     void put(int u, int space){
26         for(auto i = G[u].begin(); i != G[u].end(); ++i){
27             for(int j = 0; j < space; ++j)
28                 cout << " ";
29             cout << i->first << endl;
30             put(i->second, space + 1);
31         }
32     }
33 }tree;
34 int main(){
35     int n;
36     string str;
37     while(cin >> n && n){
38         tree.init();
39         for(int i = 0; i < n; ++i){
40             cin >> str;
41             str += '\\';
42             tree.insert(str);
43         }
44         tree.put(0, 0);
45         cout << endl;
46     }
47 }

```

## 8.5 Stammering Aliens

```

1  /* hash 字串 + 二分搜尋 */
2  #define ull unsigned long long int
3  const int maxn = 40000+5;
4  const ull seed = 131;
5  ull pw[maxn], hhash[maxn], hhash2[maxn];
6  int m, len;
7  char str[maxn];
8  map<ull, int> mp;
9  void init(){
10     hhash[0] = 0;
11     for(int i = len-1; i >= 0; --i){
12         hhash[i] = (hhash[i+1] * seed + str[i]);
13     }
14 }
15 int check(int x){
16     for(int i = 0; i + x - 1 < len; ++i){
17         ull tmp = hhash[i] - (hhash[i + x] * pw[x]);
18         hhash2[i] = tmp;
19     }
20     sort(hhash2, hhash2 + len - x + 1);
21     int cnt = 0;
22     for(int i = 0; i < len - x + 1; ++i){
23         if(i && hhash2[i] == hhash2[i-1])
24             cnt++;
25         else{

```

```

26             if(cnt >= m) return 1;
27             cnt = 1;
28         }
29     }
30     if(cnt >= m) return 1;
31     return 0;
32 }
33 int main(){
34     pw[0] = 1;
35     for(int i = 1; i < maxn; ++i)
36         pw[i] = (pw[i-1] * seed);
37     while(scanf("%d", &m) && m){
38         scanf("%s", str);
39         len = strlen(str);
40         init();
41         int lef = 1, rig = len + 1;
42         while(lef < rig){
43             int mid = (lef + rig) >> 1;
44             if(check(mid))
45                 lef = mid + 1;
46             else rig = mid;
47         }
48         int ans = rig - 1;
49         if(!ans){
50             puts("none");
51             continue;
52         }
53         int pos;
54         mp.clear();
55         for(int i = 0; i + ans - 1 < len; ++i){
56             ull tmp = hhash[i] - hhash[i + ans] *
57                 pw[ans];
58             mp[tmp]++;
59             if(mp[tmp] >= m) pos = i;
60         }
61         printf("%d %d\n", ans, pos);
62     }
63     return 0;
64 }

```

## 8.6 Fabled Rooks

```

1  /* 特定排序後放入格子
2  以右邊大小排序 要從左邊開始放
3  以左邊大小排序 要從右邊開始放 */
4  int n;
5  const int maxn = 5000+5;
6  struct Edge{
7      int lef, rig, pos, idx;
8      bool operator < (const Edge &rhs) const{
9          if(rig != rhs.rig)
10             return rig < rhs.rig;
11          else
12             return lef < rhs.lef;
13      }
14 }x[maxn], y[maxn];
15 bool used[maxn];
16 bool solve_x(){
17     memset(used, false, sizeof(used));
18     for(int i = 0; i < n; ++i){
19         x[i].pos = 0;
20         for(int j = x[i].lef; j <= x[i].rig; ++j){
21             if(!used[j]){
22                 x[i].pos = j;
23                 used[j] = true;
24                 break;
25             }
26         }
27         if(x[i].pos == 0) return false;
28     }
29     return true;
30 }
31 bool solve_y(){
32     memset(used, false, sizeof(used));
33     for(int i = 0; i < n; ++i){

```

```

34     y[i].pos = 0;
35     for(int j = y[i].lef; j <= y[i].rig; ++j){
36         if(!used[j]){
37             y[i].pos = j;
38             used[j] = true;
39             break;
40         }
41     }
42     if(y[i].pos == 0) return false;
43 }
44 return true;
45 }
46 int main(){
47     while(cin >> n && n){
48         int x1, y1, x2, y2;
49         for(int i = 0; i < n; ++i){
50             cin >> x1 >> y1 >> x2 >> y2;
51             x[i].lef = min(x1, x2);
52             x[i].rig = max(x1, x2);
53             y[i].lef = min(y1, y2);
54             y[i].rig = max(y1, y2);
55             x[i].idx = y[i].idx = i;
56             x[i].pos = y[i].pos = 0;
57         }
58         sort(x, x + n);
59         sort(y, y + n);
60         if(!solve_x() || !solve_y()) cout <<
            "IMPOSSIBLE" << endl;
61         else{
62             int ans_x[maxn], ans_y[maxn];
63             for(int i = 0; i < n; ++i){
64                 ans_x[x[i].idx] = x[i].pos;
65                 ans_y[y[i].idx] = y[i].pos;
66             }
67             for(int i = 0; i < n; ++i)
68                 cout << ans_x[i] << " " << ans_y[i]
69                     << endl;
70         }
71     }

```

## 9 DP

### 9.1 Crested Ibis vs Monster

```

1  /* dp 背包 - 重量/價值/可重複使用
2  9 3
3  8 3
4  4 2
5  2 1
6  0 3 3 3 3 3 3 3 6
7  0 2 2 2 2 3 3 3 5
8  0 1 1 2 2 3 3 3 4
9  因為這題可以重複使用同一條魔法
10 所以可以這樣 dp */
11 int a[10000+5], b[10000+5];
12 int dp[10000+5][10000+5];
13 int main(){
14     int h, n;
15     cin >> h >> n;
16     for(int i = 1; i <= n; i++){
17         cin >> a[i] >> b[i];
18     }
19     memset(dp, 0x3f3f3f3f, sizeof(dp));
20     dp[0][0] = 0;
21     for(int i = 1; i <= n; i++){
22         for(int j = 0; j <= h; j++){
23             dp[i][j] = min(dp[i-1][j], dp[i][max(0, j
24                 - a[i])] + b[i]);
25         }
26     }
27     cout << dp[n][h] << endl;

```

### 9.2 dpd Knapsack 1

```

1  /* dp 背包 - 時間/數量/價值 - 第幾分鐘符合
2  w[i]: 3
3  陣列每一格代表的意義是最大上限為 index
4  時可以放入的最大 value
5  0 0 0 30 30 30 30 30 30
6  w[i]: 4
7  0 0 0 30 50 50 50 80 80
8  w[i]: 5
9  0 0 0 30 50 60 60 80 90 */
10 int main(){
11     int N, W;
12     cin >> N >> W;
13     int w[10000+5], v[10000+5];
14     for(int i = 0; i < N; i++){
15         cin >> w[i] >> v[i];
16     }
17     long long int dp[10000+5];
18     memset(dp, 0, sizeof(dp));
19     for(int i = 0; i < N; i++){
20         for(int j = W; j >= w[i]; j--){
21             dp[j] = max(dp[j], dp[j - w[i]] + v[i]);
22         }
23     }
24     cout << dp[W] << endl;

```

### 9.3 Homer Simpson

```

1  /* dp 背包 - 時間/數量 - 漢堡
2  3 5 54
3  吃 3 分鐘漢堡時
4  0 -1 -1 1 -1 -1 2 -1 -1 3 -1 -1 4 -1 -1 5 -1 -1 6 -1
5  -1 7 -1 -1 8 -1 -1 9 -1 -1 10 -1 -1 11 -1 -1 12
6  -1 -1 13 -1 -1 14 -1 -1 15 -1 -1 16 -1 -1 17 -1
7  -1 18
8  吃 5 分鐘漢堡時 (更新)
9  0 -1 -1 1 -1 1 2 -1 2 3 2 3 4 3 4 5 4 5 6 5 6 7 6 7 8
10  7 8 9 8 9 10 9 10 11 10 11 12 11 12 13 12 13 14
11  13 14 15 14 15 16 15 16 17 16 17 18
12  只有當該時間可剛好吃滿漢堡時會更新
13 全部初始設 -1，用以判斷 譬如當 1 分鐘時
14 吃不了任何漢堡*/
15 int main(){
16     int m, n, t;
17     while(cin >> m >> n >> t){
18         int dp[10000+5];
19         memset(dp, -1, sizeof(dp));
20         dp[0] = 0;
21         for(int i = m; i <= t; i++){
22             if(dp[i - m] != -1){
23                 dp[i] = max(dp[i], dp[i - m] + 1);
24             }
25         }
26         for(int i = n; i <= t; i++){
27             if(dp[i - n] != -1){
28                 dp[i] = max(dp[i], dp[i - n] + 1);
29             }
30         }
31         // 時間無法剛好吃滿的時候
32         if(dp[t] == -1){
33             for(int i = t; i >= 0; i--){
34                 if(dp[i] != -1){
35                     cout << dp[i] << " " << t - i <<
36                         endl;
37                     break;
38                 }
39             }
40         }
41         else cout << dp[t] << endl;
42     }

```

### 9.4 Let Me Count The Ways

```

1  /* dp - 時間/數量 - 硬幣排序
2  要湊出 17
3  1 1 1 1 2 2 2 2 2 4 4 4 4 6 6 */
4  int main(){
5     long long int n;
6     long long int dp[30000+5];

```



```

7   int coin[] = {1, 5, 10, 25, 50};
8   memset(dp, 0, sizeof(dp));
9   // 直接把 dp 做好
10  dp[0] = 1;
11  for(int i = 0; i < 5; i++)
12      for(int j = coin[i]; j < 30000+5; j++)
13          if(dp[j - coin[i]] != -1)
14              dp[j] += dp[j - coin[i]];
15  while(cin >> n){
16      if(dp[n] == 1)
17          cout << "There is only " << dp[n] << "
18              way to produce " << n << " cents
19              change." << endl;
20      else
21          cout << "There are " << dp[n] << " ways
22              to produce " << n << " cents change."
23              << endl;
24  }
25 }

```

```

14      rig--;
15  }
16  return 1;
17 }
18 int main(){
19     int t;
20     cin >> t;
21     while(t--){
22         cin >> str;
23         memset(dp, 0x3f3f3f3f, sizeof(dp));
24         dp[0] = 0;
25         for(int i = 0; i < str.size(); ++i)
26             for(int j = 0; j <= i; ++j)
27                 if(str[i] == str[j])
28                     if(check_palindromes(j, i))
29                         if(dp[i+1] > dp[j] + 1)
30                             dp[i+1] = dp[j] + 1;
31         cout << dp[str.size()] << endl;
32     }
33 }

```

## 9.5 Luggage

```

1  /* dp 背包 - 重量/是否成立
2  7 7 13 1
3  1 1 0 0 0 0 0 1 1 0 0 0 0 1 1 1 0 0 0 0 1 1 0 0 0 0 0
4  Note: dp[0] = true */
5  int main(){
6      int t;
7      cin >> t;
8      cin.ignore();
9      while(t--){
10         string str;
11         getline(cin, str);
12         vector<int> v;
13         stringstream ss;
14         int num, cnt = 0, sum = 0;
15         bool dp[4000+5];
16         memset(dp, false, sizeof(dp));
17         ss << str;
18         while(ss >> num){
19             cnt++;
20             sum += num;
21             v.emplace_back(num);
22         }
23         if(sum & 1){
24             cout << "NO" << endl;
25             continue;
26         }
27         dp[0] = true;
28         for(int i = 0; i < v.size(); i++)
29             for(int j = sum; j >= v[i]; j--)
30                 if(dp[j - v[i]])
31                     dp[j] = true;
32         cout << (dp[sum/2] ? "YES" : "NO") << endl;
33     }
34 }

```

## 9.6 Partitioning by Palindromes

```

1  /* string & dp - 字串長度判斷迴文
2  r a c e c a r
3  i = 0, j = 0
4  -> r = r, dp[1] = dp[0] + 1 = 1
5  i = 1, j = 0
6  -> 因 a != r, dp[2] = 0x3f3f3f3f
7  i = 1, j = 1
8  -> 因 a = a, dp[2] = dp[1] + 1 = 2 */
9  bool check_palindromes(int lef, int rig){
10     // 比較字串兩端都是迴文
11     while(lef < rig){
12         if(str[lef] != str[rig]) return 0;
13         lef++;

```

## 9.7 SuperSale

```

1  /* dp 背包 - 重量/價值/不可重複使用
2  第一個人的負重: 23
3  0 0 0 0 52 52 52 52 52 54 54 54 54 106 106 106 106
4      106 106 106 106 106 151 151
5  第二個人的負重: 20
6  0 0 0 0 52 52 52 52 52 54 54 54 54 106 106 106 106
7      106 106 106 106
8  第三個人的負重: 20
9  0 0 0 0 52 52 52 52 52 54 54 54 54 106 106 106 106
10     106 106 106 106
11 第四個人的負重: 26
12 0 0 0 0 52 52 52 52 52 54 54 54 54 106 106 106 106
13     106 106 106 106 106 151 151 151 151 151 */
14 struct Edge{
15     int p;
16     int w;
17 }edge[1000+5];
18 int main(){
19     int t;
20     cin >> t;
21     while(t--){
22         int n; cin >> n;
23         for(int i = 0; i < n; i++)
24             cin >> edge[i].p >> edge[i].w;
25         int g, total = 0;
26         cin >> g;
27         for(int i = 0; i < g; i++){
28             int pw; cin >> pw;
29             int dp[30+5];
30             memset(dp, 0, sizeof(dp));
31             for(int j = 0; j < n; j++)
32                 for(int k = pw; k >= edge[j].w; k--)
33                     dp[k] = max(dp[k], dp[k -
34                         edge[j].w] + edge[j].p);
35             total += dp[pw];
36         }
37         cout << total << endl;
38     }
39 }

```

## 9.8 Walking on the Safe Side

```

1  /* dp - 地圖更新
2  更新地圖
3  一張如下的地圖 其 dp 更新方法為加上和加左的路
4  0 0 0 0 0
5  0 1 0 0 0
6  0 0 1 0 1
7  0 0 0 0 0
8  1 1 1 1 1

```

```

9 1 0 1 2 3
10 1 1 0 2 0
11 1 2 2 4 4 */
12 bool mp[100+5][100+5];
13 long long int dp[100+5][100+5];
14 int main(){
15     int t; cin >> t;
16     bool space = false;
17     while(t--){
18         if(space) cout << endl;
19         else space = true;
20         int r, c; cin >> r >> c;
21         cin.ignore();
22         memset(mp, false, sizeof(mp));
23         memset(dp, 0, sizeof(dp));
24         string str;
25         for(int i = 0; i < r; i++){
26             getline(cin, str);
27             int n, num;
28             stringstream ss(str);
29             ss >> n;
30             while(ss >> num)
31                 mp[n][num] = true;
32         }
33         dp[1][1] = 1;
34         for(int i = 1; i <= r; i++){
35             for(int j = 1; j <= c; j++){
36                 if(mp[i][j]) continue;
37                 if(i > 1)
38                     dp[i][j] += dp[i-1][j];
39                 if(j > 1)
40                     dp[i][j] += dp[i][j-1];
41             }
42         }
43         cout << dp[r][c] << endl;
44     }
45 }

```

## 9.9 Cutting Sticks

```

1 /* dp - 動態切割取最小
2 100
3 3
4 25 50 75
5 dp:
6 0 0 50 125 200
7 0 0 0 50 125
8 0 0 0 0 50
9 0 0 0 0 0
10 0 0 0 0 0 */
11 int main(){
12     int l;
13     while(cin >> l && l){
14         int n;
15         cin >> n;
16         vector<int> s(n+2);
17         s[0] = 0;
18         for(int i = 1; i <= n; ++i)
19             cin >> s[i];
20         // 從現在開始 n 的數量變為 n + 1
21         s[++n] = l;
22         int dp[n+5][n+5];
23         memset(dp, 0, sizeof(dp));
24         // r: 切幾段 b: 起點 c: 中間點 e: 終點
25         for(int r = 2; r <= n; ++r){
26             for(int b = 0; b < n; ++b){
27                 // 如果從 b 開始切 r 刀會超出長度就
28                 // break
29                 if(b + r > n) break;
30                 // e: 從 b 開始切 r 刀
31                 int e = b + r;
32                 dp[b][e] = 0x3f3f3f3f;
33                 // c: 遍歷所有從 b 開始到 e
34                 // 結束的中間點
35                 for(int c = b + 1; c < e; ++c){

```

```

34 // dp[b][c] 從 b 到 c 最少 cost +
35 // dp[c][e] 從 c 到 e 最少 cost
36 // s[e] - s[b] 兩段之間的 cost
37 dp[b][e] = min(dp[b][e], dp[b][c]
38 // + dp[c][e] + s[e] - s[b]);
39 }
40 }
41 cout << "The minimum cutting is " << dp[0][n]
42 << "." << endl;
43 }
44 }

```

## 9.10 Race to 1

```

1 /* dp - 數量
2 期望值、質數、dfs */
3 const int N = 1000000;
4 bool sieve[N+5];
5 vector<int> pri;
6 double dp[N+5];
7 // 線性篩
8 void Linear_Sieve(){
9     for (int i = 2; i < N; i++){
10         if (!sieve[i])
11             pri.push_back(i);
12         for (int p: pri){
13             if (i * p >= N) break;
14             sieve[i * p] = true;
15             if (i % p == 0) break;
16         }
17     }
18 }
19 double dfs(int n){
20     if(dp[n] != -1) return dp[n];
21     dp[n] = 0;
22     if(n == 1) return dp[n];
23     int total = 0, prime = 0;
24     for(int i = 0; i < pri.size() && pri[i] <= n;
25         i++){
26         total++;
27         if(n % pri[i]) continue;
28         prime++;
29         dp[n] += dfs(n/pri[i]);
30     }
31     // 算期望值
32     dp[n] = (dp[n] + total)/prime;
33     return dp[n];
34 }
35 int main(){
36     int t, num, ca = 1;
37     for(int i = 0; i <= N; i++)
38         dp[i] = -1;
39     Linear_Sieve();
40     cin >> t;
41     while(t--){
42         cin >> num;
43         cout << "Case " << ca++ << ": " << fixed <<
44             setprecision(10) << dfs(num) << endl;
45     }
46 }

```

## 9.11 Apple

```

1 /* dp - 數量
2 col = 蘋果 n
3 row = 盤子 m
4 * 0 1 2 3 4
5 1 1 1 1 1
6 2 1 1 2 2 3
7 3 1 1 2 3 4 */
8 int dp[10+5];
9 int main(){

```

```

10 int t; cin >> t;
11 while(t--){
12     int n, m;
13     cin >> m >> n;
14     memset(dp, 0, sizeof(dp));
15     dp[0] = 1;
16     for(int i = 1; i <= n; ++i)
17         for(int j = i; j <= m; ++j)
18             dp[j] += dp[j - i];
19     cout << dp[m] << endl;
20 }
21 }

```

## 9.12 Stamps

```

1 /* dp - dfs/分配可能性並更新 */
2 const int maxn = 100+5;
3 int h, k, r, maxi = 0;
4 int x[maxn], y[maxn];
5 int ans[maxn]; // 存可貼出最大郵票值的面額
6 void dfs(int i){
7     // 若 x[i] 的 i 多於可貼的郵票數量
8     if(i >= k){
9         if(r > maxi){
10             maxi = max(maxi, r);
11             for(int i = 0; i < k; ++i)
12                 ans[i] = x[i];
13         }
14         return;
15     }
16     // 存此層尚未更新前的 r、y 值，因為 dfs
17     // 完要回去上一層
18     int r_before_this_layer = r;
19     int y_before_this_layer[maxn];
20     for(int j = 0; j < maxn; ++j)
21         y_before_this_layer[j] = y[j];
22     // next: 下一可考慮的郵票面額
23     // postage: 貼完郵票的總面額(y的idx)
24     // num: 要貼幾張
25     // x[i-1] 要 -1 是因為 x 從 0 開始存第一面額
26     for(int next = x[i-1] + 1; next <= r + 1; ++next){
27         x[i] = next;
28         for(int postage = 0; postage < x[i-1] * h;
29             ++postage){
30             if(y[postage] >= h) continue;
31             for(int num = 1; num <= h - y[postage];
32                 ++num)
33                 if(y[postage] + num < y[postage + num]
34                     * next) && (postage + num * next
35                         < maxn)
36                     y[postage + num * next] =
37                         y[postage] + num;
38         }
39         // 更新現在連續最大值到多少
40         while(y[r+1] < 0x3f3f3f) r++;
41         // x 可貼面額種類多 1
42         dfs(i+1);
43         // 還原 r、y 值
44         r = r_before_this_layer;
45         for(int j = 0; j < maxn; ++j)
46             y[j] = y_before_this_layer[j];
47     }
48 }
49 int main(){
50     while(cin >> h >> k && h && k){
51         memset(x, 0, sizeof(x));
52         memset(y, 0x3f3f3f, sizeof(y));
53         x[0] = 1;
54         r = h;
55         // x[0] = 1, 1 張郵票可貼到的最大值
56         for(int i = 0; i <= r; ++i)
57             y[i] = i;
58         maxi = 0;
59         dfs(1);
60     }
61 }

```

```

54 for(int i = 0; i < k; ++i)
55     printf("%3d", ans[i]);
56     printf(" ->%3d\n", maxi);
57 }
58 }

```

## 9.13 Evacuation Plan

```

1 /* dp - 路徑/隊伍分配救難所 */
2 const int maxn = 4000+5;
3 int path[maxn][maxn];
4 long long int dp[maxn][maxn];
5 struct Edge{
6     int idx, position;
7     bool operator < (const Edge &rhs) const{
8         return position < rhs.position;
9     }
10 }team[maxn], shelter[maxn];
11 int main(){
12     int n;
13     while(cin >> n){
14         for(int i = 1; i <= n; ++i){
15             cin >> team[i].position;
16             team[i].idx = i;
17         }
18         sort(team + 1, team + n + 1);
19         int m; cin >> m;
20         for(int i = 1; i <= m; ++i){
21             cin >> shelter[i].position;
22             shelter[i].idx = i;
23         }
24         sort(shelter + 1, shelter + m + 1);
25         memset(dp, 0x3f3f3f3f, sizeof(dp));
26         dp[1][0] = 0;
27         for(int i = 1; i <= m; ++i){
28             for(int j = i; j <= n; ++j){
29                 // dp[i][j] = min(dp[i][j-1],
30                     // dp[i-1][j-1]) +
31                     // abs(team[j].position -
32                     // shelter[i].position);
33                 if(dp[i][j-1] <= dp[i-1][j-1]){
34                     dp[i][j] = min(dp[i][j-1],
35                         dp[i-1][j-1]) +
36                         abs(team[j].position -
37                             shelter[i].position);
38                     path[i][j] = 0; //
39                     // 從左邊來，前面的 teams 有人來
40                     // j shelter
41                 }
42                 else{
43                     dp[i][j] = min(dp[i][j-1],
44                         dp[i-1][j-1]) +
45                         abs(team[j].position -
46                             shelter[i].position);
47                     path[i][j] = 1; //
48                     // 從左上來，前面的 teams 不會來
49                     // j shelter
50                 }
51             }
52         }
53         int now_shelter = m;
54         int ans[maxn];
55         //
56         // 紀錄路徑，若從左邊來，上一隊也來此；若從右邊來，上
57         for(int i = n; i > 0; --i){
58             ans[team[i].idx] =
59                 shelter[now_shelter].idx;
60             now_shelter -= path[now_shelter][i];
61         }
62         cout << dp[m][n] << endl;
63         for(int i = 1; i < n; ++i)
64             cout << ans[i] << " ";
65         cout << ans[n] << endl;
66     }
67 }

```

## 9.14 Ladies Choice

```

1  /* dp - ladies & men */
2  const int maxn = 1000+5;
3  int n;
4  int man[maxn][maxn], manidx[maxn], lady[maxn][maxn],
   ladyidx[maxn];
5  int dp[maxn];
6  deque<int> dq;
7  void dp_func(){
8      while(!dq.empty()){
9          int man_now = dq.front();
10         dq.pop_front();
11         // manidx 現在指著的 lady
12         int lady1 = manidx[man_now];
13         // man 目前最想要的 lady
14         int lady_first = man[man_now][lady1];
15         // ladyidx 現在指著的 man
16         int man1 = ladyidx[lady_first];
17         if(man1 == 0){
18             dp[man_now] = lady_first;
19             ladyidx[lady_first] = man_now;
20         }
21         else if(lady[lady_first][man1] >
22             lady[lady_first][man_now]){
23             dp[man_now] = lady_first;
24             manidx[man1]++;
25             dq.emplace_back(man1);
26             ladyidx[lady_first] = man_now;
27         }
28         else{
29             dq.emplace_back(man_now);
30             manidx[man_now]++;
31         }
32     }
33 }
34 int main(){
35     int t; cin >> t;
36     bool space = false;
37     while(t--){
38         cin >> n;
39         if(space) cout << endl;
40         space = true;
41         memset(man, 0, sizeof(man));
42         memset(lady, 0, sizeof(lady));
43         memset(manidx, 0, sizeof(manidx));
44         memset(ladyidx, 0, sizeof(ladyidx));
45         dq.clear();
46         for(int i = 1; i <= n; ++i){
47             for(int j = 1; j <= n; ++j){
48                 cin >> man[i][j];
49                 dq.emplace_back(i);
50                 manidx[i] = 1;
51             }
52             for(int i = 1; i <= n; ++i){
53                 for(int j = 1; j <= n; ++j){
54                     int man_lady;
55                     cin >> man_lady;
56                     lady[i][man_lady] = j;
57                 }
58             }
59             dp_func();
60             for(int i = 1; i <= n; ++i)
61                 cout << dp[i] << endl;
62 }

```

## 10 LIS

### 10.1 Wavio Sequence

```

1  /* LIS、LDS */
2  int N;

```

```

3  const int maxn = 10000 + 5;
4  int length[maxn];
5  int seq[maxn], revseq[maxn];
6  void LIS(vector<int> &s){
7      if(s.size() == 0) return;
8      vector<int> v;
9      v.emplace_back(s[0]);
10     seq[0] = 1;
11     for(int i = 1; i < s.size(); ++i){
12         int n = s[i];
13         if(n > v.back())
14             v.push_back(n);
15         else
16             *lower_bound(v.begin(), v.end(), n) = n;
17         seq[i] = v.size();
18     }
19     return;
20 }
21 void LDS(vector<int> &s){
22     if(s.size() == 0) return;
23     vector<int> v;
24     v.emplace_back(s[0]);
25     revseq[0] = 1;
26     for(int i = 1; i < s.size(); ++i){
27         int n = s[i];
28         if(n > v.back())
29             v.push_back(n);
30         else
31             *lower_bound(v.begin(), v.end(), n) = n;
32         revseq[i] = v.size();
33     }
34     return;
35 }
36 int main(){
37     while(cin >> N){
38         vector<int> s(N), revs(N);
39         for(int i = 0; i < N; i++){
40             cin >> s[i];
41             revs[i] = s[i];
42         }
43         reverse(revs.begin(), revs.end());
44         LIS(s);
45         LDS(revs);
46         reverse(revseq, revseq + N);
47         int maxi = -1;
48         for(int i = 0; i < N; i++){
49             if(min(seq[i], revseq[i]) > maxi)
50                 maxi = min(seq[i], revseq[i]);
51         }
52         cout << maxi * 2 - 1 << endl;
53     }

```

### 10.2 Robots II

```

1  /* LIS
2  No.: 2 4 11 13 25 28 41 42
3  LIS: 1 2 3 4 4 5 5 5
4  num: 1 1 1 1 1 2 2 4
5  path: -1 0 1 2 2 3 3 5 */
6  const int maxn = 100+5;
7  int r, c;
8  vector<int> G;
9  int LIS[maxn * maxn], num[maxn * maxn], path[maxn *
   maxn];
10 bool garbage[maxn][maxn];
11 void show_path(int n){
12     if(path[n] != -1) show_path(path[n]);
13     if((n != G.size() - 1) || garbage[r][c]) cout <<
14         " " << G[n];
15 }
16 int main(){
17     int ca = 1;
18     while(cin >> r >> c && (r != -1) && (c != -1)){
19         memset(garbage, false, sizeof(garbage));
20         G.clear();
21         int x, y;

```

```

21 while(cin >> x >> y && x && y){
22     garbage[x][y] = true;
23 }
24 // 紀錄有垃圾的點的編號
25 for(int i = 1; i <= r; ++i){
26     for(int j = 1; j <= c; ++j){
27         if(garbage[i][j]) G.emplace_back((i -
28             1) * c + j);
29     }
30 }
31 // 如果終點沒有垃圾，假設他有
32 if(!garbage[r][c]) G.emplace_back(r * c);
33 G.emplace_back(0);
34 // i 和 j
35 // 是按照編號大小順序由小排到大的垃圾編號
36 for(int i = 0; i < G.size(); ++i){
37     LIS[i] = 1;
38     num[i] = 1;
39     path[i] = -1;
40     for(int j = 0; j < i; ++j){
41         // 判斷垃圾的 col 前後
42         if(((G[j] - 1) % c) <= ((G[i] - 1) %
43             c)){
44             // num 是經過的路徑數量。path
45             // 是從誰來
46             if(LIS[i] == LIS[j] + 1){
47                 num[i] += num[j];
48             }
49             else if(LIS[i] < LIS[j] + 1){
50                 LIS[i] = LIS[j] + 1;
51                 num[i] = num[j];
52                 path[i] = j;
53             }
54         }
55     }
56 }
57 G.pop_back();
58 // 要把假設還回去
59 if(!garbage[r][c]) LIS[G.size() - 1]--;
60 cout << "CASE#" << ca++ << ": " <<
    LIS[G.size() - 1] << " " << num[G.size()
    - 1];
61 show_path(G.size() - 1);
62 cout << endl;
63 }
64 }

```

## 11 Math

### 11.1 Big Mod

```

1 '''
2 Mod
3 pow(x, y, z) = x^y % z
4 '''
5 # python 如何讀取直到 EOF 用 try except
6 try:
7     while True:
8         # input().split() 用空格切開讀取一整行
9         # map (型態, input().split()) 才能把值全讀成
10         int
11         B, P, M = map(int, input().split())
12         print(pow(B, P, M))
13 except EOFError:
14     exit

```

### 11.2 Bubble Sort Expect Value

```

1 /* 數論 期望值算法:
2 擲一枚公平的六面骰子，其每次「點數」的期望值是 3.5

```

```

3 E(x) = 1 * 1/6 + 2 * 1/6 + 3 * 1/6 + 4 * 1/6 + 5 *
4     1/6 + 6 * 1/6
5 = (1 + 2 + 3 + 4 + 5 + 6)/6 = 3.5
6 bubble sort 每兩兩之間交換機率是 1/2
7 總共會做 C(n, 2) 次
8 E(x) = C(n, 2) * 1/2 = (n * (n - 1))/2 * 1/2 */
9 int t, ca = 1;
10 cin >> t;
11 while(t--){
12     long long int n;
13     cin >> n;
14     cout << "Case " << ca++ << ": ";
15     // 如果 (n * (n - 1)) 可以被 4 整除
16     // 代表最後答案會是整數，否則會是分數
17     if((n * (n - 1)) % 4){
18         cout << ( (n * (n - 1)) / 2 ) << "/" << endl;
19     }
20     else{
21         cout << ( (n * (n - 1)) / 2 ) / 2 << endl;
22     }
23 }

```

### 11.3 Fraction Floor Sum

```

1 /* 數論
2 [N/i] == M
3 -> M <= N/i < M + 1
4 -> N/(M+1) < i <= N/M */
5 int main(){
6     long long int N;
7     cin >> N;
8     long long int ans = 0;
9     for(long long int i = 1; i <= N; i++){
10         long long int M = N / i, n = N / M;
11         // 總共會有 n - i 個的 [N/i] 值都是 M
12         ans += (n - i + 1) * M;
13         // 更新跳過 以免重複計算
14         i = n;
15     }
16     cout << ans << endl;
17 }

```

### 11.4 How Many Os

```

1 /* 數論 */
2 int main(){
3     long long int n, m;
4     while(cin >> n >> m && (n >= 0) && (m >= 0)){
5         long long int total1 = 0, total2 = 0;
6         long long int ten = 1, tmp = n-1;
7         while(tmp >= 10){
8             if(tmp % 10 == 0){
9                 tmp /= 10;
10                total1 += (tmp - 1) * ten + ((n-1) %
11                    ten) + 1;
12            }
13            else{
14                tmp /= 10;
15                total1 += tmp * ten;
16            }
17            ten *= 10;
18        }
19        ten = 1; tmp = m;
20        while(tmp >= 10){
21            if(tmp % 10 == 0){
22                tmp /= 10;
23                total2 += (tmp - 1) * ten + (m % ten)
24                    + 1;
25            }
26            else{
27                tmp /= 10;
28                total2 += tmp * ten;
29            }
30        }
31    }
32 }

```

```

28         ten *= 10;
29     }
30     if(n == 0) total1--;
31     cout << total2 - total1 << endl;
32 }
33 }

```

## 11.5 Number of Pairs

```

1  /* 數論
2  upper_bound ex:
3  10 20 30 30 40 50
4  upper_bound for element 30 is at index 4
5  lower_bound ex:
6  10 20 30 40 50
7  lower_bound for element 30 at index 2 */
8  int main(){
9      int t;
10     cin >> t;
11     while(t--){
12         int n, l, r;
13         vector<int> v;
14         cin >> n >> l >> r;
15         int num;
16         for(int i = 0; i < n; i++){
17             cin >> num;
18             v.emplace_back(num);
19         }
20         sort(v.begin(), v.end());
21         long long int ans = 0;
22         for(int i = 0; i < n; i++){
23             ans += (upper_bound(v.begin() + i + 1,
24                               v.end(), r - v[i]) -
25                    lower_bound(v.begin() + i + 1,
26                               v.end(), l - v[i]));
27         }
28         cout << ans << endl;
29     }
30 }

```

## 11.6 ORXOR

```

1  /* bitwise operator 二進位制數論
2  如何切區段，之所以要1<<n是為了可以跑000~111
3  i = 0, binary i = 000
4  0 : 1 5 7
5  i = 1, binary i = 001
6  1 : 1 5 7
7  i = 2, binary i = 010, 看得出來切了一刀
8  2 : 1 | 5 7
9  i = 3, binary i = 011
10 3 : 1 | 5 7
11 i = 4, binary i = 100, 為了要切在index=2, 所以才要1<<j
12 4 : 1 5 | 7
13 i = 5, binary i = 101
14 5 : 1 5 | 7
15 i = 6, binary i = 110
16 6 : 1 | 5 | 7
17 i = 7, binary i = 111
18 7 : 1 | 5 | 7
19 可以觀察出來，前兩位 bit 是 1 時代表的意義是切在哪裡
20 */
21 int main(){
22     int n; cin >> n;
23     int num[20+7];
24     memset(num, 0, sizeof(num));
25     for(int i = 1; i <= n; i++){
26         cin >> num[i];
27         // 不知道為甚麼只有 2147483647 給過
28         int mini = 2147483647;
29         // 1 << n = n * 2
30         for(int i = 0; i < (1 << n); i++){
31             int XOR = 0, OR = 0;
32             for(int j = 1; j <= n; j++){

```

```

32             OR |= num[j];
33             if((i & (1 << j))){
34                 XOR ^= OR;
35                 OR = 0;
36             }
37         }
38         XOR ^= OR;
39         mini = min(mini, XOR);
40     }
41     cout << mini << endl;
42 }

```

## 11.7 X drawing

```

1  /* 數論畫圖 */
2  int main(){
3      long long int n;
4      long long int a, b;
5      long long int p, q, r, s;
6      cin >> n >> a >> b;
7      cin >> p >> q >> r >> s;
8      for(long long int i = p; i <= q; i++){
9          for(long long int j = r; j <= s; j++){
10             if(abs(i - a) == abs(j - b)) cout << '#';
11             else cout << '.';
12             cout << endl;
13         }
14     }

```

## 11.8 Playing With Stones

```

1  /* Nim Game - SG 函數 */
2  long long int SG(long long int n){
3      return n % 2 == 0 ? n/2 : SG(n/2);
4  }
5  int main(){
6      int t;
7      cin >> t;
8      while(t--){
9          int n;
10         cin >> n;
11         long long int a, v = 0;
12         for(int i = 0; i < n; ++i){
13             cin >> a;
14             v ^= SG(a);
15         }
16         if(v) cout << "YES" << endl;
17         else cout << "NO" << endl;
18     }
19 }

```

## 12 Binary Search

### 12.1 Fill the Containers

```

1  /*binary search 變形*/
2  int binary_search(int arr[maxn], int lef, int rig,
3                    int mini){
4      if(lef > rig) return mini;
5      int amount = 1, fill = 0;
6      int mid = (lef + rig) >> 1;
7      for(int i = 0; i < n; ++i){
8          if(amount > m) break;
9          fill += arr[i];
10         if(fill > mid){
11             fill = arr[i];
12             amount++;
13         }
14     }
15     if(!flag && amount <= m) mini = mid;

```

```

15     if(flag && amount == m) mini = mid;
16     if(amount == m){
17         flag = true;
18         return binary_search(arr, lef, mid - 1, mid);
19     }
20     else if(amount < m){
21         return binary_search(arr, lef, mid - 1, mini);
22     }
23     else{
24         return binary_search(arr, mid + 1, rig, mini);
25     }
26 }
27 int main(){
28     int ca = 1;
29     while(cin >> n >> m){
30         flag = false;
31         int arr[maxn];
32         int maxi = 0, sum = 0;
33         for(int i = 0; i < n; ++i){
34             cin >> arr[i];
35             sum += arr[i];
36             maxi = max(maxi, arr[i]);
37         }
38         cout << binary_search(arr, maxi, sum, maxi)
39             << endl;
40     }

```

## 12.2 Where is the marble

```

1  /*upper_bound & lower_bound*/
2  int main(){
3      int N, Q;
4      int ca = 1;
5      while(cin >> N >> Q && N && Q){
6          vector<int> v(N);
7          for(int i = 0; i < N; ++i) cin >> v[i];
8          sort(v.begin(), v.end());
9          cout << "CASE# " << ca++ << " " << endl;
10         int marble;
11         for(int i = 0; i < Q; ++i){
12             cin >> marble;
13             int lef = lower_bound(v.begin(), v.end(),
14                                   marble) - v.begin();
15             int rig = upper_bound(v.begin(), v.end(),
16                                   marble) - v.begin();
17             if(lef == rig) cout << marble << " not
18                 found" << endl;
19             else{
20                 cout << marble << " found at " << lef
21                     + 1 << endl;
22             }
23         }
24     }
25 }

```

## 13 Graph

### 13.1 Maximum sum on a torus

```

1  /* Prefix sum in Graph*/
2  const int maxn = 80;
3  const int inf = 0x3f3f3f3f;
4  int arr[maxn*2 + 5][maxn*2 + 5];
5  int prefix_sum[maxn*2 + 5][maxn*2 + 5];
6  int ans[maxn*2];
7  int n;
8  int maxSub(int start){
9      int maxi, dp;
10     maxi = dp = ans[start];
11     for(int i = start + 1; i < start + n; ++i){
12         dp += ans[i];

```

```

13         maxi = max(maxi, dp);
14     }
15     return maxi;
16 }
17 int main(){
18     int t;
19     cin >> t;
20     while(t--){
21         memset(arr, 0, sizeof(arr));
22         cin >> n;
23         for(int i = 0; i < n; ++i)
24             for(int j = 0; j < n; ++j){
25                 cin >> arr[i][j];
26                 arr[n+i][j] = arr[i][n+j] =
27                     arr[n+i][n+j] = arr[i][j];
28             }
29         int len = 2*n;
30         memset(prefix_sum, 0, sizeof(prefix_sum));
31         for(int i = 0; i < len; ++i)
32             for(int j = 0; j < len; ++j){
33                 if(i == 0) prefix_sum[i][j] =
34                     arr[i][j];
35                 else prefix_sum[i][j] =
36                     prefix_sum[i-1][j] + arr[i][j];
37             }
38         int maxi = -inf;
39         for(int i = 0; i < len; ++i){
40             for(int j = i; j < i + n && j < len; ++j){
41                 for(int k = 0; k < len; ++k){
42                     if(i == 0) ans[k] =
43                         prefix_sum[j][k];
44                     else ans[k] = prefix_sum[j][k] -
45                         prefix_sum[i-1][k];
46                 }
47                 for(int k = 0; k < n; ++k){
48                     int answer = maxSub(k);
49                     maxi = max(maxi, answer);
50                 }
51             }
52         }
53         cout << maxi << endl;
54     }
55 }

```

## 14 Segement Tree

### 14.1 Frequent values

```

1  /* Segement Tree & RMQ (Range Sum Query)
2  idx: 1 2 3 4 5 6 7 8 9 10
3  num: -1 -1 1 1 1 1 3 10 10 10
4  fre: 2 2 4 4 4 4 1 3 3 3
5  border
6  left: 1 1 3 3 3 3 7 8 8 8
7  right: 2 2 6 6 6 6 7 10 10 10 */
8  # define Lson(x) x << 1
9  # define Rson(x) (x << 1) + 1
10 const int maxn = 1e5+5;
11 struct Tree{
12     int lef, rig, value;
13 }tree[4 * maxn];
14 struct Num{
15     int lef, rig, value, fre;
16 }num[maxn];
17 // 建立 segment tree
18 void build(int lef, int rig, int x){
19     tree[x].lef = lef;
20     tree[x].rig = rig;
21     // 區塊有多長，題目詢問的重點
22     if(lef == rig){
23         tree[x].value = num[lef].fre;
24         return;
25     }
26     int mid = (lef + rig) >> 1;

```



```

27     build(lef, mid, Lson(x));
28     build(mid + 1, rig, Rson(x));
29     tree[x].value = max(tree[Lson(x)].value,
30         tree[Rson(x)].value);
31 }
32 // 查詢 segement tree
33 int query(int lef, int rig, int x){
34     // 題目所查詢的區間剛好都在同個區塊上, num[lef].v
35     // == num[rig].v
36     if(num[lef].value == num[rig].value) return rig -
37         lef + 1;
38     int ans = 0;
39     // 查詢的左區間邊界切到區塊, 且此區間有數個區塊
40     if(lef > num[lef].lef){
41         // 計算切到的區間大小
42         ans = num[lef].rig - lef + 1;
43         //
44         // 更新左邊界至被切區塊的右邊界加一, 就不會切到區
45         lef = num[lef].rig + 1;
46     }
47     // 查詢的右區間邊界切到區塊, 且此區間有數個區塊
48     if(rig < num[rig].rig){
49         // 計算切到的區間大小, 並找出最大
50         ans = max(ans, rig - num[rig].lef + 1);
51         // 更新右邊界
52         rig = num[rig].lef - 1;
53     }
54     //
55     // 如果左邊界大於右邊界, 表示不需要再進行查詢直接回傳
56     if(lef > rig) return ans;
57     if(tree[x].lef >= lef && tree[x].rig <= rig)
58         return tree[x].value;
59     int mid = (tree[x].lef + tree[x].rig) >> 1;
60     if(lef <= mid) ans = max(ans, query(lef, rig,
61         Lson(x)));
62     if(mid < rig) ans = max(ans, query(lef, rig,
63         Rson(x)));
64     return ans;
65 }
66 int main(){
67     int n, q;
68     while(cin >> n && n){
69         cin >> q;
70         int start = 1;
71         for(int i = 1; i <= n; ++i){
72             cin >> num[i].value;
73             if(num[i].value != num[i-1].value){
74                 for(int j = start; j < i; ++j){
75                     num[j].rig = i - 1;
76                     num[j].fre = i - start;
77                 }
78                 start = num[i].lef = i;
79             }
80             else num[i].lef = start;
81         }
82         // 最後一段 [start, n]
83         for(int j = start; j <= n; ++j){
84             num[j].rig = n;
85             num[j].fre = n - start + 1;
86         }
87         build(1, n, 1);
88         int lef, rig;
89         for(int i = 0; i < q; ++i){
90             cin >> lef >> rig;
91             cout << query(lef, rig, 1) << endl;
92         }
93     }
94 }
95
96 /* Dijkstra 捷徑票 */
97 int n, m, S, T;
98 const int inf = 1e9;
99 const int maxn = 20000 + 5;
100 struct Edge{
101     int v, w;
102 };
103 struct Item{
104     int u, dis;
105     // 取路徑最短
106     bool operator < (const Item &other) const{
107         return dis > other.dis;
108     }
109 };
110 int dis[maxn], from[maxn];
111 vector<Edge> G[maxn];
112 void dijkstra(int s){
113     for(int i = 0; i <= n; i++){
114         dis[i] = inf;
115     }
116     dis[s] = 0;
117     for(int i = 0; i <= n; i++){
118         from[i] = i;
119     }
120     priority_queue<Item> pq;
121     pq.push({s, 0});
122     while(!pq.empty()){
123         // 取路徑最短的點
124         Item now = pq.top();
125         pq.pop();
126         if(now.dis > dis[now.u])
127             continue;
128         // 鬆弛 更新
129         // 把與 now.u 相連的點都跑一遍
130         for(Edge e : G[now.u]){
131             if(dis[e.v] > now.dis + e.w){
132                 dis[e.v] = now.dis + e.w;
133                 from[e.v] = now.u;
134                 pq.push({e.v, dis[e.v]});
135             }
136         }
137     }
138 }
139
140 deque<int> ans;
141 void dfs(int T){
142     ans.emplace_back(T);
143     if(from[T] != T) dfs(from[T]);
144 }
145
146 int main(){
147     bool space = false;
148     while(cin >> n >> S >> T){
149         if(!space) space = true;
150         else cout << endl;
151         for(int i = 0; i <= n; i++){
152             G[i].clear();
153         }
154         ans.clear();
155         cin >> m;
156         int u, v, w;
157         for(int i = 0; i < m; i++){
158             cin >> u >> v >> w;
159             // 無向圖
160             G[u].push_back({v, w});
161             G[v].push_back({u, w});
162         }
163         dijkstra(S);
164         dfs(T);
165         int ori = dis[T];
166         int mini = dis[T], state = 0;
167         int ticket;
168         cin >> ticket;
169         for(int i = 0; i < ticket; ++i){
170             cin >> u >> v >> w;
171             G[u].push_back({v, w});
172             G[v].push_back({u, w});
173             dijkstra(S);
174             if(dis[T] < mini){
175                 mini = min(mini, dis[T]);
176                 state = u;
177                 ans.clear();
178                 dfs(T);
179             }
180         }
181     }
182 }

```

## 15 Dijkstra

### 15.1 Airport Express



```

78     }
79     G[u].pop_back();
80     G[v].push_back({u, w});
81     dijkstra(S);
82     if(dis[T] < mini){
83         mini = min(mini, dis[T]);
84         state = v;
85         ans.clear();
86         dfs(T);
87     }
88     G[v].pop_back();
89 }
90 for(int i = ans.size()-1; i > 0; i--){
91     cout << ans[i] << " ";
92     cout << ans[0];
93     cout << endl;
94     if(mini == ori)
95         cout << "Ticket Not Used" << endl;
96     else
97         cout << state << endl;
98     cout << mini << endl;
99 }
100 }

```

## 16 Kruskal

### 16.1 Qin Shi Huang Road System

```

1  /* kruskal disjoint set dfs */
2  const int maxn = 1000 + 5;
3  int n, m;
4  int x[maxn], y[maxn], p[maxn];
5  struct Edge{
6      int u, v;
7      double w;
8      bool operator < (const Edge &rhs) const{
9          return w < rhs.w;
10     }
11 }edge[maxn * maxn];
12 vector<Edge> G[maxn];
13 int parent[maxn];
14 // 計算兩點之間的距離
15 double dist(int a, int b){
16     double x2 = (x[a] - x[b]) * (x[a] - x[b]);
17     double y2 = (y[a] - y[b]) * (y[a] - y[b]);
18     return sqrt(x2 + y2);
19 }
20 // disjoint set
21 int find(int x){
22     return x == parent[x] ? x : parent[x] = find(parent[x]);
23 }
24 bool unite(int a, int b){
25     int x = find(a);
26     int y = find(b);
27     if(x == y) return false;
28     parent[x] = y;
29     return true;
30 }
31 double kruskal(){
32     m = 0; // m: 邊的數量
33     for(int i = 0; i < n; ++i)
34         for(int j = i + 1; j < n; ++j)
35             edge[m++] = (Edge){i, j, dist(i, j)};
36     sort(edge, edge + m);
37     for(int i = 0; i < n; ++i){
38         parent[i] = i;
39         G[i].clear();
40     }
41     double total = 0.0;
42     int edge_cnt = 0;
43     for(int i = 0; i < m; ++i){
44         int u = edge[i].u, v = edge[i].v;
45         double cnt = edge[i].w;

```

```

46         if(unite(u, v)){
47             G[u].push_back((Edge){u, v, cnt});
48             G[v].push_back((Edge){v, u, cnt});
49             total += cnt;
50             if(++edge_cnt == n-1) break;
51         }
52     }
53     return total;
54 }
55 double maxcost[maxn][maxn];
56 bool visited[maxn];
57 void dfs(int u){
58     visited[u] = true;
59     for(int i = 0; i < G[u].size(); ++i){
60         int v = G[u][i].v;
61         if(visited[v]) continue;
62         double cost = G[u][i].w;
63         maxcost[u][v] = maxcost[v][u] = cost;
64         // 更新 MST 樹上的點到 v 點的距離
65         for(int j = 0; j < n; ++j)
66             if(visited[j])
67                 maxcost[j][v] = maxcost[v][j] = max(maxcost[j][u], cost);
68     }
69     dfs(v);
70 }
71 void solve(){
72     double total = kruskal();
73     memset(maxcost, 0, sizeof(maxcost));
74     memset(visited, false, sizeof(visited));
75     dfs(0);
76     double ans = -1;
77     // 把所有點都遍歷一次
78     for(int i = 0; i < n; ++i)
79         for(int j = i + 1; j < n; ++j)
80             ans = max(ans, (p[i] + p[j]) / (total - maxcost[i][j]));
81     printf("%.2lf\n", ans);
82 }
83 int main(){
84     int t;
85     scanf("%d", &t);
86     while(t--){
87         scanf("%d", &n);
88         for(int i = 0; i < n; ++i)
89             scanf("%d%d%d", &x[i], &y[i], &p[i]);
90         solve();
91     }
92     return 0;
93 }

```

## 17 Bipartite Graph

### 17.1 Claw Decomposition

```

1  /*二分圖 Bipartite*/
2  const int maxn = 300+5;
3  int n;
4  int color[maxn];
5  vector<vector<int>> v(maxn);
6  bool dfs(int s){
7      for(auto it : v[s]){
8          if(color[it] == -1){
9              //
10             // 如果與點相連又還未填色，填塞成與原點不同的另一色
11             color[it] = 3 - color[s];
12             // 同樣對此點去判定與此點相連的點的填色
13             if(!dfs(it)) return false;
14         }
15         if(color[s] == color[it]){
16             // 如果相鄰兩點同色，回傳 false
17             return false;
18         }
19     }
20 }

```

```

19     return true;
20 }
21 void isBipartite(){
22     bool flag = true;
23     for(int i = 1; i <= n; ++i){
24         if(color[i] == -1){
25             // 如果還未填色過，就先填色成
26             // 1，並對與此點相連的點都 dfs 判定填色
27             color[i] = 1;
28             flag &= dfs(i);
29         }
30     }
31     if(flag) cout << "YES" << endl;
32     else cout << "NO" << endl;
33 }
34 int main(){
35     while(cin >> n && n){
36         for(int i = 1; i <= n; ++i) v[i].clear();
37         memset(color, -1, sizeof(color));
38         int a, b;
39         while(cin >> a >> b && (a || b)){
40             v[a].emplace_back(b);
41             v[b].emplace_back(a);
42         }
43         isBipartite();
44     }
45 }

```

```

43     }
44     return cnt;
45 }
46 int main(){
47     int t;
48     cin >> t;
49     while(t--){
50         int N;
51         cin >> N;
52         bn = 0, gn = 0;
53         for(int i = 0; i <= N; ++i) G[i].clear();
54         int h;
55         string sex, music, sport;
56         for(int i = 0; i < N; ++i){
57             cin >> h >> sex >> music >> sport;
58             if(sex == "M")
59                 lef[bn++] = People(h, music, sport);
60             else
61                 rig[gn++] = People(h, music, sport);
62         }
63         for(int i = 0; i < bn; ++i)
64             for(int j = 0; j < gn; ++j)
65                 if(check(lef[i], rig[j]))
66                     G[i].emplace_back(j);
67         cout << N - Hungarian() << endl;
68     }
69 }

```

## 17.2 Guardian of Decency

```

1  /* 二分圖最大匹配
2  匈牙利演算法 Hungarian algorithm */
3  const int maxn = 500+5;
4  int bn, gn;
5  int match[maxn];
6  bool visited[maxn];
7  vector<vector<int>> G(maxn);
8  struct People{
9      int h;
10     string music, sport;
11     // constructor
12     People(){
13     }
14     People(int h, string music, string sport){
15         this->h = h;
16         this->music = music;
17         this->sport = sport;
18     }
19 }lef[maxn], rig[maxn];
20 bool check(People boy, People girl){
21     if(abs(boy.h - girl.h) <= 40 && boy.music ==
22         girl.music && boy.sport != girl.sport) return
23         true;
24     return false;
25 }
26 bool dfs(int s){
27     for(int i = 0; i < G[s].size(); ++i){
28         int v = G[s][i];
29         if(visited[v]) continue;
30         visited[v] = true;
31         // 如果這個女生還沒被配對過，直接匹配
32         // 如果已經被配對，則根據這個女生所配對的對象
33         // dfs 重新匹配所有人的對象
34         if(match[v] == -1 || dfs(match[v])){
35             match[v] = s;
36             return true;
37         }
38     }
39     return false;
40 }
41 int Hungarian(){
42     int cnt = 0;
43     memset(match, -1, sizeof(match));
44     for(int i = 0; i < bn; ++i){
45         memset(visited, false, sizeof(visited));
46         if(dfs(i)) cnt++;
47     }
48 }

```

## 17.3 Taxi Cab Scheme

```

1  /* 二分圖最大匹配
2  匈牙利演算法 Hungarian algorithm */
3  const int maxn = 500+5;
4  int n;
5  int match[maxn];
6  bool visited[maxn];
7  vector<int> G[maxn];
8  struct People{
9      int s, x1, y1, x2, y2;
10     bool operator < (const People & rhs) const {
11         return s < rhs.s;
12     }
13 }p[maxn];
14 bool check(People boy, People girl){
15     int tmp = boy.s + abs(boy.x2 - boy.x1) +
16         abs(boy.y2 - boy.y1) + abs(boy.x2 - girl.x1)
17         + abs(boy.y2 - girl.y1);
18     if(tmp < girl.s) return true;
19     return false;
20 }
21 bool dfs(int s){
22     for(int i = 0; i < G[s].size(); ++i){
23         int v = G[s][i];
24         if(visited[v]) continue;
25         visited[v] = true;
26         if(match[v] == -1 || dfs(match[v])){
27             match[v] = s;
28             return true;
29         }
30     }
31     return false;
32 }
33 int Hungarian(){
34     int cnt = 0;
35     memset(match, -1, sizeof(match));
36     for(int i = 0; i < n; ++i){
37         memset(visited, false, sizeof(visited));
38         if(dfs(i)) cnt++;
39     }
40     return cnt;
41 }
42 int main(){
43     int t;
44     scanf("%d", &t);
45     while(t--){

```

```

44     scanf("%d", &n);
45     for(int i = 0; i < n; ++i) G[i].clear();
46     for(int i = 0; i < n; ++i){
47         int h, m;
48         scanf("%d:%d", &h, &m);
49         p[i].s = h * 60 + m;
50         scanf("%d%d%d%d", &p[i].x1, &p[i].y1,
51             &p[i].x2, &p[i].y2);
52     }
53     sort(p, p + n);
54     for(int i = 0; i < n; ++i)
55         for(int j = i + 1; j < n; ++j)
56             if(check(p[i], p[j]))
57                 G[i].push_back(j);
58     printf("%d\n", n - Hungarian());
59 }

```

## 18 Function

### 18.1 CHAR

```

1 isdigit()
2 isalnum() // 判斷字母 // 數字
3 isalpha()
4 islower()
5 isupper()
6 isblank() // 判斷 即 space 和 \t
7 toupper()
8 tolower()

```

### 18.2 string

```

1 int main(){
2     string str;
3     while(cin >> str){
4         // substr 取 str idx 2~4 的值
5         cout << str.substr(2, 4) << endl;
6         // substr 取 str idx 2 以後的所有值
7         cout << str.substr(2) << endl;
8
9         string subst;
10        cin >> subst;
11        // str.append 連接字串
12        cout << str.append(subst) << endl;
13
14        char s[100], ss[100];
15        cin >> s >> ss;
16
17        char *p;
18        // strstr 回傳在s裡找到ss後的整個字串(從 ss
19        // idx 0 到結束)
20        p = strstr(s, ss);
21        cout << p << endl;
22        // strstr 也可以單純用來找字串
23        if(p != NULL) cout << "yes" << endl;
24        else cout << "no" << endl;
25    }
26 }

```

### 18.3 setprecision

```

1 double cnt = 3.5555;
2 cout << fixed << setprecision(3) << cnt ;

```

## 18.4 GCD LCM

```

1 int gcd(int a, int b){
2     return (b == 0 ? a : gcd(b, a % b));
3 }
4 int lcm(int a, int b){
5     return a * b / gcd(a, b);
6 }
7
8 /* 輾轉相除法 - 求兩數是否互質
9 如果兩數互質 最終結果其中一方為0時 另一方必為1
10 若兩數有公因數 最終結果其中一方為0時 另一方必不為1 */
11 while ( ( num1 % num2 ) != 0 && ( num2 % num1 ) !=
12     0 );

```

## 18.5 reverse

```

1 int a[10] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};
2 reverse(a, a + 5);
3
4 vector<int> v;
5 reverse(v.begin(), v.end());
6
7 string str = "123";
8 reverse(str.begin(), str.end());
9 cout << str << endl; //321

```

## 18.6 sort

```

1 priority_queue<int, vector<int>, less<int>> // 大到小
2 priority_queue<int, vector<int>, greater<int>> //
3     小到大
4 int arr[] = {4, 5, 8, 3, 7, 1, 2, 6, 10, 9};
5 sort(arr, arr+10);
6
7 vector<int> v;
8 sort(v.begin(), v.end()); //小到大
9
10 int cmp(int a, int b){
11     return a > b;
12 }
13 sort(v.begin(), v.end(), cmp); //大到小

```

## 18.7 map

```

1 int main(){
2     map<string, string> mp;
3     map<string, string>::iterator iter;
4     map<string, string>::reverse_iterator iter_r;
5
6     mp.insert(pair<string, string>("r000", "zero"));
7
8     mp["r123"] = "first";
9
10    for(iter = mp.begin(); iter != mp.end(); iter++)
11        cout<<iter->first<<" "<<iter->second<<endl;
12    for(iter_r = mp.rbegin(); iter_r != mp.rend();
13        iter_r++)
14        cout<<iter_r->first<<"
15        "<<iter_r->second<<endl;
16
17    iter = mp.find("r123");
18    mp.erase(iter);
19
20    iter = mp.find("r123");
21    if(iter != mp.end())
22        cout<<"Find, the value is
23        "<<iter->second<<endl;
24    else
25

```

```
22 |     cout<<"Do not Find"<<endl;
23 |
24 |     mp.clear();
25 |     mp.erase(mp.begin(), mp.end());
26 | }
```

## 18.8 set

```
1 | int main(){
2 |     set<int> st {1, 6, 8}; // 直接初始化的寫法
3 |     st.insert(1); // 也可以這樣寫就好
4 |     set<int>::iterator iter;
5 |
6 |     // 如果有找到，就會傳回正確的 iterator，否則傳回
7 |     // st.end()
8 |     if (iter != st.end()) {
9 |         cout << "Found: " << *iter << endl;
10 |     } else {
11 |         cout << "Not found." << endl;
12 |     }
13 |     // cout: Found: 6
14 |
15 |     // 取值：使用 iterator
16 |     x = *st.begin(); // set 中的第一個元素(最小的元素)
17 |     x = *st.rbegin(); // set
18 |     // 中的最後一個元素(最大的元素)
19 |
20 |     // search
21 |     iter = st.find(6);
22 |     auto it = st.find(x); // binary search, O(log(N))
23 |     auto it = st.lower_bound(x); // binary search,
24 |     // O(log(N))
25 |     auto it = st.upper_bound(x); // binary search,
26 |     // O(log(N))
27 |
28 |     st.clear();
29 | }
```