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# 1 Data Structure

## 1.1 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 }
```

## 1.2 BIT

```

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

## 1.3 Segment tree

```

1 int dfs(int lef, int rig){
2     if(lef + 2 == rig){
3         if(num[lef] > num[rig-1]){
4             return lef;
5         }
6         else{
7             return rig-1;
8         }
9     }
10    int mid = (lef + rig)/2;
11    int p1 = dfs(lef, mid);
12    int p2 = dfs(mid, rig);
13    if(num[p1] > num[p2]){
14        return p1;
15    }
16    else{
17        return p2;
18    }
19 }
```

## 1.4 Trie

```

1 const int MAXL = ; // 自己填
2 const int MAXC = ;
3 struct Trie {
4     int nex[MAXL][MAXC];
5     int len[MAXL];
6     int sz;
7     void init() {
8         memset(nex, 0, sizeof(nex));
9         memset(len, 0, sizeof(len));
10        sz = 0;
11    }
12 }
```

```

12 void insert(const string &str) {
13     int p = 0;
14     for (char c : str) {
15         int id = c - 'a';
16         if (!nex[p][id]) {
17             nex[p][id] = ++sz;
18         }
19         p = nex[p][id];
20     }
21     len[p] = str.length();
22 }
23 vector<int> find(const string &str, int i) {
24     int p = 0;
25     vector<int> ans;
26     for (; i < str.length(); i++) {
27         int id = str[i] - 'a';
28         if (!nex[p][id]) {
29             return ans;
30         }
31         p = nex[p][id];
32         if (len[p]) {
33             ans.pb(len[p]);
34         }
35     }
36     return ans;
37 }
38 };

```

## 1.5 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)
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 }

```

## 2 Divide and Conquer

### 2.1 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        }
19        k++;
20    }
21    for(int k = lef; k < rig; ++k) arr[k] = buf[k];
22    return ans;
23 }

```

## 3 DP

### 3.1 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){ // 從後往回推
24         if(dp[a][i] < b){
25             ans += (1 << i);
26             a = dp[a][i];
27         }
28     }
29     cout << ans + 1 << endl;
30 }

```

### 3.2 Josephus

```

1 int josephus (int n, int k) {
2     // 有 n 個人圍成一圈，每 k 個一次
3     return n > 1 ? (josephus(n-1, k) + k) % n : 0;
4 }
5 // 回傳最後一人的編號，0 index

```

### 3.3 LCS

```

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

```

### 3.4 LIS

```

1 int LIS(vector<int> &a) { // Longest Increasing
2     Subsequence
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         }
8     }
9     return s.size();
10 }

```

```

6     } else {
7         *lower_bound(s.begin(), s.end(), a[i],
8             [](int x, int y) {return x < y;}) = a[i];
9     }
10 }
11 return s.size();
12 }

```

## 4 Enumerate

### 4.1 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;
15     for(int i = 0; i < N; ++i) cin >> A[i];
16     dfs(s1, 0, N/2, 0); // 折半枚舉
17     dfs(s2, N/2, N, 0);
18     long long int ans = 0;
19     // 題目:枚舉集合 Sx 的數字 Sxi，找出 Sy
20     // 集合內小於等於 T-Sxi 中最大的數 Syj
21     for(auto &x : s1){
22         auto it = s2.upper_bound(T - x);
23         long long int y = *(--it);
24         if(x + y <= T) ans = max(ans, x + y);
25     }
26     cout << ans << endl;
27 }

```

## 5 Graph

### 5.1 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 }

```

```

27     }
28     }
29 }
30 return true;
31 }

```

### 5.2 Dijkstra

```

1 struct Item{
2     int u, dis;
3     // 取路徑最短
4     bool operator < (const Item &other) const{
5         return dis > other.dis;
6     }
7 };
8 int dis[maxn];
9 vector<Edge> G[maxn];
10 void dijkstra(int s){
11     for(int i = 0; i <= n; i++){
12         dis[i] = inf;
13     }
14     dis[s] = 0;
15     priority_queue<Item> pq;
16     pq.push({s, 0});
17     while(!pq.empty()){
18         // 取路徑最短的點
19         Item now = pq.top();
20         pq.pop();
21         if(now.dis > dis[now.u]){
22             continue;
23         }
24         // 鬆弛更新，把與 now.u 相連的點都跑一遍
25         for(Edge e : G[now.u]){
26             if(dis[e.v] > now.dis + e.w){
27                 dis[e.v] = now.dis + e.w;
28                 pq.push({e.v, dis[e.v]});
29             }
30         }
31     }
32 }

```

### 5.3 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 }

```

### 5.4 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
21     if(a != b){
22         if(parent[a] < parent[b]){
23             parent[a] += parent[b];
24             parent[b] = a;
25         }
26         else{
27             parent[b] += parent[a];
28             parent[a] = b;
29         }
30     }
31 }
32 void kruskal(){
33     memset(parent, -1, sizeof(parent));
34     sort(edge, edge + m);
35     int i, j;
36     for(i = 0, j = 0; i < n - 1 && j < m; i++){
37         // 如果 u 和 v 的祖先相同，則 j++
38         // (祖先相同代表會產生環 所以不要)
39         while(find(edge[j].u) == find(edge[j].v)) j++;
40         // 若部會產生環 則讓兩點之間產生橋
41         // (連接兩顆子生成樹)
42         unite(edge[j].u, edge[j].v);
43         j++;
44     }
45 }

```

## 5.5 KM

```

1 const int X = 50; // x的點數，等於y的點數
2 const int Y = 50; // y的點數
3 int adj[X][Y]; // 精簡過的adjacency matrix
4 int lx[X], ly[Y]; // vertex labeling
5 int mx[X], my[Y]; //
6 // x各點的配對對象、y各點的配對對象
7 int q[X], *qf, *qb; // BFS queue
8 int p[X]; // BFS
9 // parent，交錯樹之偶點，指向上一個偶點
10 bool vx[X], vy[Y]; // 記錄是否在交錯樹上
11 int dy[Y], pdy[Y]; // 表格
12
13 void relax(int x){ // relaxation
14     for (int y=0; y<Y; ++y)
15         if (adj[x][y] != 1e9)
16             if (lx[x] + ly[y] - adj[x][y] < dy[y]){
17                 dy[y] = lx[x] + ly[y] - adj[x][y];
18                 pdy[y] = x; //
19                 // 記錄好是從哪個樹葉連出去的
20             }
21 }
22
23 void reweight(){ // 調整權重、調整表格
24     int d = 1e9;
25     for (int y=0; y<Y; ++y) if (!vy[y]) d = min(d, dy[y]);
26     for (int x=0; x<X; ++x) if (vx[x]) lx[x] -= d;
27     for (int y=0; y<Y; ++y) if (vy[y]) ly[y] += d;
28     for (int y=0; y<Y; ++y) if (!vy[y]) dy[y] -= d;
29 }
30
31 void augment(int x, int y){ // 擴充路徑
32     for (int ty; x != -1; x = p[x], y = ty){
33         ty = mx[x]; my[y] = x; mx[x] = y;
34     }
35 }

```

```

30 }
31 bool branch1(){ // 延展交錯樹：使用既有的等邊
32     while (qf < qb)
33         for (int x=*qf++, y=0; y<Y; ++y)
34             if (!vy[y] && lx[x] + ly[y] == adj[x][y]){
35                 vy[y] = true;
36                 if (my[y] == -1){
37                     augment(x, y);
38                     return true;
39                 }
40                 int z = my[y];
41                 *qb++ = z; p[z] = x; vx[z] = true;
42                 relax(z);
43             }
44     return false;
45 }
46 bool branch2(){ // 延展交錯樹：使用新添的等邊
47     for (int y=0; y<Y; ++y){
48         if (!vy[y] && dy[y] == 0){
49             vy[y] = true;
50             if (my[y] == -1){
51                 augment(pdy[y], y);
52                 return true;
53             }
54             int z = my[y];
55             *qb++ = z; p[z] = pdy[y]; vx[z] = true;
56             relax(z);
57         }
58     }
59     return false;
60 }
61 int Hungarian(){
62     // 初始化vertex labeling
63     // memset(lx, 0, sizeof(lx)); // 任意值皆可
64     memset(ly, 0, sizeof(ly));
65     for (int x=0; x<X; ++x)
66         for (int y=0; y<Y; ++y)
67             lx[x] = max(lx[x], adj[x][y]);
68
69     // x側每一個點，分別建立等邊交錯樹。
70     memset(mx, -1, sizeof(mx));
71     memset(my, -1, sizeof(my));
72     for (int x=0; x<X; ++x){
73         memset(vx, false, sizeof(vx));
74         memset(vy, false, sizeof(vy));
75         memset(dy, 0x7f, sizeof(dy));
76         qf = qb = q;
77         *qb++ = x; p[x] = -1; vx[x] = true; relax(x);
78         while (true){
79             if (branch1()) break;
80             reweight();
81             if (branch2()) break;
82         }
83     }
84     // 計算最大權完美匹配的權重
85     int weight = 0;
86     for (int x=0; x<X; ++x)
87         weight += adj[x][mx[x]];
88     return weight;
89 }

```

## 5.6 Dinic

```

1 // Maximum Flow
2 const int V = 100, E = 1000;
3 int adj[V]; // adjacency lists，初始化為-1。
4 struct Element {int b, r, next;} e[E*2];
5 int en = 0;
6 void addedge(int a, int b, int c){
7     e[en] = (Element){b, c, adj[a]}; adj[a] = en++;
8     e[en] = (Element){a, 0, adj[b]}; adj[b] = en++;
9 }
10 int d[V]; // 最短距離
11 bool visit[V]; // BFS/DFS visit record
12 int q[V]; // queue

```

```

13 int BFS(int s, int t){ // 計算最短路徑，求出容許圖
14     memset(d, 0x7f, sizeof(d));
15     memset(visit, false, sizeof(visit));
16     int qn = 0;
17     d[s] = 0;
18     visit[s] = true;
19     q[qn++] = s;
20
21     for (int qf=0; qf<qn; ++qf){
22         int a = q[qf];
23         for (int i = adj[a]; i != -1; i = e[i].next){
24             int b = e[i].b;
25             if (e[i].r > 0 && !visit[b]){
26                 d[b] = d[a] + 1;
27                 visit[b] = true;
28                 q[qn++] = b;
29                 if (b == t) return d[t];
30             }
31         }
32     }
33     return V;
34 }
35 int DFS(int a, int df, int s, int t){ //
36     求出一條最短擴充路徑，並擴充流量
37     if (a == t) return df;
38     if (visit[a]) return 0;
39     visit[a] = true;
40     for (int i = adj[a]; i != -1; i = e[i].next){
41         int b = e[i].b;
42         if (e[i].r > 0 && d[a] + 1 == d[b]){
43             int f = DFS(b, min(df, e[i].r), s, t);
44             if (f){
45                 e[i].r -= f;
46                 e[i^1].r += f;
47                 return f;
48             }
49         }
50     }
51     return 0;
52 }
53 int dinitz(int s, int t){
54     int flow = 0;
55     while (BFS(s, t) < V)
56         while (true){
57             memset(visit, false, sizeof(visit));
58             int f = DFS(s, 1e9, s, t);
59             if (!f) break;
60             flow += f;
61         }
62     return flow;
63 }

```

## 5.7 Bipatirate

```

1 const int maxn = 300 + 5;
2 int n, color[maxn];
3 vector<vector<int>> v(maxn);
4 bool dfs(int s){
5     for(auto it : v[s]){
6         if(color[it] == -1){
7             color[it] = 3 - color[s];
8             if(!dfs(it)){
9                 return false;
10            }
11        }
12        if(color[s] == color[it]){
13            return false;
14        }
15    }
16    return true;
17 }
18 void isBipatirate(){
19     bool flag = true;
20     for(int i = 1; i <= n; ++i){
21         if(color[i] == -1){

```

```

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

```

## 5.8 Hungarian algorithm

```

1 const int maxn = 500+5;
2 int t, N, bn, gn, match[maxn];
3 bool visited[maxn];
4 vector<vector<int>> G(maxn);
5 struct People{
6     int h;
7     string music, sport;
8     People(){ }
9     People(int h, string music, string sport){
10         this->h = h;
11         this->music = music;
12         this->sport = sport;
13     }
14 }lef[maxn], rig[maxn];
15 bool check(People boy, People girl){
16     if(abs(boy.h - girl.h) <= 40 && boy.music ==
17         girl.music && boy.sport != girl.sport) return
18         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 < bn; ++i){
37         memset(visited, false, sizeof(visited));
38         if(dfs(i)) cnt++;
39     }
40     return cnt;
41 }
42 int main(){
43     cin >> t;
44     while(t--){
45         cin >> N;
46         bn = 0, gn = 0;
47         for(int i = 0; i <= N; ++i) G[i].clear();
48         int h;
49         string sex, music, sport;
50         for(int i = 0; i < N; ++i){

```

```

49         cin >> h >> sex >> music >> sport;
50         if(sex == "M") lef[bn++] = People(h,
            music, sport);
51         else rig[gn++] = People(h, music, sport);
52     }
53     for(int i = 0; i < bn; ++i){
54         for(int j = 0; j < gn; ++j)
55             if(check(lef[i], rig[j]))
56                 G[i].emplace_back(j);
57     }
58     cout << N - Hungarian() << endl;
59 }

```

## 5.9 LCA

```

1  /*最低共同祖先*/
2  // 此 node 下有機類 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] =
                parent[parent[j][i-1]][i-1];
21         }
22     }
23     // 求兩點的LCA (利用倍增法)
24     int LCA(int a, int b){
25         if (depth[b] < depth[a]) swap(a, b);
26         if (depth[a] != depth[b]){
27             int dif = depth[b] - depth[a];
28             for (int i = 0; i < 20; i++){
29                 if (dif & 1) b = parent[b][i];
30                 dif >>= 1;
31             }
32         }
33         if (a == b) return a;
34         for (int i = 19; i >= 0; i--){
35             if (parent[a][i] != parent[b][i]){
36                 a = parent[a][i];
37                 b = parent[b][i];
38             }
39         }
40         return parent[a][0];
41     }
42 }

```

## 6 Other

### 6.1 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 下有機類 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     }
32     // 求兩點的LCA (利用倍增法)
33     int LCA(int a, int b){
34         if (depth[b] < depth[a]) swap(a, b);
35         if (depth[a] != depth[b]){
36             int dif = depth[b] - depth[a];
37             for (int i = 0; i < 20; i++){
38                 if (dif & 1) b = parent[b][i];
39                 dif >>= 1;
40             }
41         }
42         if (a == b) return a;
43         for (int i = 19; i >= 0; i--){
44             if (parent[a][i] != parent[b][i]){
45                 a = parent[a][i];
46                 b = parent[b][i];
47             }
48         }
49         return parent[a][0];
50     }
51     long long int dist[maxn];
52     // 從 0 開始到每個點的距離
53     void distance(){
54         for (int u = 0; u < N; ++u){
55             for(int i = 0; i < G[u].size(); ++i){
56                 dist[G[u][i].v] = dist[u] + G[u][i].w;
57             }
58         }
59     }
60     int main(){
61         while(cin >> N && N){
62             memset(dist, 0, sizeof(dist));
63             memset(parent, 0, sizeof(parent));
64             memset(depth, 0, sizeof(depth));
65             memset(siz, 0, sizeof(siz));
66             for(int i = 0; i <= N; ++i){
67                 G[i].clear();
68             }
69             for(int i = 1; i < N; ++i){
70                 int u, w;
71                 cin >> u >> w;
72                 G[u].push_back({i, w});
73                 parent[i][0] = u;
74             }
75             find_parent();
76             dfs(0, 0);
77             distance();
78             int s; cin >> s;
79             bool space = false;
80             for(int i = 0; i < s; ++i){
81                 int a, b;
82                 cin >> a >> b;
83                 int lca = LCA(a, b);
84                 if(space) cout << " ";
85                 space = true;
86                 cout << (dist[a] + dist[b]) - (dist[lca]
                        * 2);
87             }
88             cout << endl;
89         }
90     }

```

```
86 }
87 }
```

## 6.2 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    }
```

## 7 DP

### 7.1 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 - a[i])] + b[i]);
24         }
25     }
26     cout << dp[n][h] << endl;
27 }
```

### 7.2 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(){
```

```
10 int N, W;
11 cin >> N >> W;
12 int w[100000+5], v[100000+5];
13 for(int i = 0; i < N; i++){
14     cin >> w[i] >> v[i];
15 }
16 long long int dp[100000+5];
17 memset(dp, 0, sizeof(dp));
18 for(int i = 0; i < N; i++){
19     for(int j = W; j >= w[i]; j--){
20         dp[j] = max(dp[j], dp[j - w[i]] + v[i]);
21     }
22 }
```

### 7.3 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             for(int i = n; i <= t; i++){
26                 if(dp[i - n] != -1){
27                     dp[i] = max(dp[i], dp[i - n] + 1);
28                 }
29             }
30             // 時間無法剛好吃滿的時候
31             if(dp[t] == -1){
32                 for(int i = t; i >= 0; i--){
33                     if(dp[i] != -1){
34                         cout << dp[i] << " " << t - i << endl;
35                         break;
36                     }
37                 }
38             }
39             else cout << dp[t] << endl;
40         }
41     }
42 }
```

### 7.4 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 1 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             }
16         }
17     }
18     while(cin >> n){
19         if(dp[n] == 1)
```

```

17         cout << "There is only " << dp[n] << "
           way to produce " << n << " cents
           change." << endl;
18     else
19         cout << "There are " << dp[n] << " ways
           to produce " << n << " cents change."
           << endl;
20     }
21 }

```

```

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 }

```

## 7.5 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
   1
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 }

```

## 7.6 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++;
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));

```

## 7.7 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
   106 106 106 106 106 151 151
4  第二個人的負重: 20
5  0 0 0 0 52 52 52 52 52 54 54 54 54 106 106 106 106
   106 106 106 106
6  第三個人的負重: 20
7  0 0 0 0 52 52 52 52 52 54 54 54 54 106 106 106 106
   106 106 106 106
8  第四個人的負重: 26
9  0 0 0 0 52 52 52 52 52 54 54 54 54 106 106 106 106
   106 106 106 106 106 151 151 151 151 151 */
10 struct Edge{
11     int p;
12     int w;
13 }edge[1000+5];
14 int main(){
15     int t;
16     cin >> t;
17     while(t--){
18         int n; cin >> n;
19         for(int i = 0; i < n; i++)
20             cin >> edge[i].p >> edge[i].w;
21         int g, total = 0;
22         cin >> g;
23         for(int i = 0; i < g; i++){
24             int pw; cin >> pw;
25             int dp[30+5];
26             memset(dp, 0, sizeof(dp));
27             for(int j = 0; j < n; j++){
28                 for(int k = pw; k >= edge[j].w; k--){
29                     dp[k] = max(dp[k], dp[k -
30                         edge[j].w] + edge[j].p);
31                 }
32                 total += dp[pw];
33             }
34             cout << total << endl;
35         }
36     }
37 }

```

## 7.8 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 }

```

## 7.9 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){
36                     // dp[b][c] 從 b 到 c 最少 cost +
37                     // dp[c][e] 從 c 到 e 最少 cost
38                     // s[e] - s[b] 兩段之間的 cost
39                     dp[b][e] = min(dp[b][e], dp[b][c]
40                                     + dp[c][e] + s[e] - s[b]);
41                 }
42             }
43         }
44         cout << "The minimum cutting is " << dp[0][n]
45             << "." << endl;

```

## 7.10 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 }

```

## 8 Math

### 8.1 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

```

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

## 8.3 Fraction Floor Sum

```

1  /* 數論
2   $[N/i] == M$ 
3   $\rightarrow M \leq N/i < M + 1$ 
4   $\rightarrow N/(M+1) < i \leq N/M$ 
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 }
```

## 8.4 How Many 0s

```

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) % ten) + 1;
11            }
12            else{
13                tmp /= 10;
14                total1 += tmp * ten;
15            }
16            ten *= 10;
17        }
18        ten = 1; tmp = m;
19        while(tmp >= 10){
20            if(tmp % 10 == 0){
21                tmp /= 10;
22                total2 += (tmp - 1) * ten + (m % ten) + 1;
23            }
24            else{
25                tmp /= 10;
26                total2 += tmp * ten;
27            }
28            ten *= 10;
29        }
30        cout << total1 - total2 << endl;
31    }
32 }
```

```

23     }
24     else{
25         tmp /= 10;
26         total2 += tmp * ten;
27     }
28     ten *= 10;
29 }
30 if(n == 0) total1--;
31 cout << total2 - total1 << endl;
32 }
33 }
```

## 8.5 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 }
```

## 8.6 ORXOR

```

1  /* bitwise operator 二進制數論
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  $1 < n$ 
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     }
29 }
```

```

27     int mini = 2147483647;
28     // 1 << n = n * 2
29     for(int i = 0; i < (1 << n); i++){
30         int XOR = 0, OR = 0;
31         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 }

```

## 8.7 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     }

```

# 9 Binary Search

## 9.1 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;
16     if(flag && amount == m) mini = mid;
17     if(amount == m){
18         flag = true;
19         return binary_search(arr, lef, mid - 1, mid);
20     }
21     else if(amount < m){
22         return binary_search(arr, lef, mid - 1, mini);
23     }
24     else{
25         return binary_search(arr, mid + 1, rig, mini);
26     }
27 }
28 int main(){
29     int ca = 1;
30     while(cin >> n >> m){
31         flag = false;
32         int arr[maxn];
33         int maxi = 0, sum = 0;
34         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 }

```

## 9.2 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 }

```

# 10 Bipartite Graph

## 10.1 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             color[it] = 3 - color[s];
11             // 同樣對此點去判定與此點相連的點的填色
12             if(!dfs(it)) return false;
13         }
14         if(color[s] == color[it]){
15             // 如果相鄰兩點同色，回傳 false
16             return false;
17         }
18     }
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 }

```

```

30     if(flag) cout << "YES" << endl;
31     else cout << "NO" << endl;
32 }
33 int main(){
34     while(cin >> n && n){
35         for(int i = 1; i <= n; ++i) v[i].clear();
36         memset(color, -1, sizeof(color));
37         int a, b;
38         while(cin >> a >> b && (a || b)){
39             v[a].emplace_back(b);
40             v[b].emplace_back(a);
41         }
42         isBipartite();
43     }
44 }

```

```

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 }

```

## 10.2 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     People(int h, string music, string sport){
14         this->h = h;
15         this->music = music;
16         this->sport = sport;
17     }
18 }lef[maxn], rig[maxn];
19 bool check(People boy, People girl){
20     if(abs(boy.h - girl.h) <= 40 && boy.music ==
21         girl.music && boy.sport != girl.sport) return
22         true;
23     return false;
24 }
25 bool dfs(int s){
26     for(int i = 0; i < G[s].size(); ++i){
27         int v = G[s][i];
28         if(visited[v]) continue;
29         visited[v] = true;
30         // 如果這個女生還沒被配對過，直接匹配
31         // 如果已經被配對，則根據這個女生所配對的對象
32         // dfs 重新匹配所有人的對象
33         if(match[v] == -1 || dfs(match[v])){
34             match[v] = s;
35             return true;
36         }
37     }
38     return false;
39 }
40 int Hungarian(){
41     int cnt = 0;
42     memset(match, -1, sizeof(match));
43     for(int i = 0; i < bn; ++i){
44         memset(visited, false, sizeof(visited));
45         if(dfs(i)) cnt++;
46     }
47     return cnt;
48 }
49 int main(){
50     int t;
51     cin >> t;
52     while(t--){
53         int N;
54         cin >> N;
55         bn = 0, gn = 0;
56         for(int i = 0; i <= N; ++i) G[i].clear();
57         int h;

```

## 11 Function

### 11.1 strstr

```

1  #include <stdio.h>
2  #include <string.h>
3
4  int main(){
5      char * c;
6      char str1[1005], str2[1005];
7      scanf("%s %s", str1, str2);
8      c = strstr(str1, str2);
9      if (c != NULL){
10         printf("Yes\n");
11     }
12     else printf("No\n");
13 }
14 // Input : Hello eLl
15 // Output : No

```

### 11.2 substr

```

1  int main(){
2      string str; //abcdef
3      cin >> str;
4      string tmp;
5      tmp = str.substr(0, 2); //ab
6      str = str.substr(2); //cdef
7      cout << tmp << " " << str;
8      return 0;
9  }

```

### 11.3 map set

```

1  .begin( ) // Return iterator to beginning
2  .end( ) // Return iterator to end
3  .empty( ) // 檢查是否為空
4  .size( ) // 回傳大小
5  mp.insert(pair<char, int>('a', 100))
6  st.insert(100) // 插入key、value
7  .erase( ) // 刪掉指定key和他的value
8  .clear( ) // 清空整個 map
9  m.find( )
10 cout << "a => " << mymap.find('a')->second << endl;
11 // 找出 map 裡 key
12 // 有沒有在裡面，如果有的話會回傳元素所在的iterator，否則傳
13 s.count() // 返回某個值元素在set的個數
14 while( !mymap.empty()){
15     cout << mymap.begin()->first << " => " <<
16         mymap.begin()->second << endl;
17     mymap.erase(mymap.begin());
18 }
19 for (auto it = mymap.begin(); it != mymap.end(); ++it)
20     cout << it->first << " => " << it->second << endl;

```

## 11.4 vector

```
1 | v.erase(v.begin() + 5) //拿掉第六個數
2 | v.erase (v.begin(), v.begin() + 3); //拿掉前三個數
```

## 11.5 setprecision

```
1 | // 將數字的小數部分設定為固定長度
2 | cnt = 3.5555;
3 | cout << fixed << setprecision(3) << cnt ;
4 | // output : 3.555
```

## 11.6 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 ) != 0 );
```

## 11.7 reverse

```
1 | int a[10] = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};
2 | reverse(a, a+5) // 轉換0~5
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
```

## 11.8 CHAR

```
1 | isdigit()
2 | isalnum() //判斷字母 // 數字
3 | isalpha()
4 | islower()
5 | isupper()
6 | isblank() //判斷是否為空格，或者 tab 健制表符，即
   | space 和 \t
7 | toupper()
8 | tolower()
```

## 11.9 sort

```
1 | priority_queue<int, vector<int>, less<int>> //大到小
2 | priority_queue<int, vector<int>, greater<int>>
   | //小到大大
3 |
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
```

## 11.10 struct

```
1 | struct area{
2 |     int a, b;
3 |     bool operator<(const area rhs) const{
4 |         return a > rhs.a || ( a == a && b > rhs.b);
5 |     }
6 |     bool operator!=(const area rhs) const{
7 |         return a != rhs.a || b != rhs.b;
8 |     }
9 | };
```

## 11.11 deque

```
1 | deque<int> que;
2 | que.push_back(10);
3 | que.push_front(20);
4 | que.front()
5 | que.back()
6 | que.pop_front()
7 | que.pop_back()
8 | cout << "Element at position 2 : " << que.at(2) << endl;
```

## 11.12 python template

```
1 | import math
2 | import operator
3 |
4 | try:
5 |     while(1):
6 |         listx = []
7 |         listx.append("...")
8 |         list_s = sorted(listx) # 小到大
9 |         list_s = sorted(listx, reverse = True) #
   |         大到小
10 |         # max(listx)
11 |         # min(listx)
12 |         # sum(listx)
13 |         # len(listx)
14 |         dicty = {}
15 |         dicty[key] = "value"
16 |         dicty= sorted(dicty.items()) # by key
17 |         dicty= sorted(dicty.items(),
   |             key=operator.itemgetter(1)) # by value
18 |         # EOF寫法
19 |         # 階層 math.factorial(3) == 6
20 |         # 絕對值 math.fabs(x)
21 |         # 無條件進位 math.ceil(3.1) == 3
22 |         # 無條件捨去 math.floor(2.9) == 2
23 |         # C n 取 k math.comb(n, k)
24 |         # math.gcd
25 |         # math.lcm
26 |         # e 次 x 冪 math.exp(x)
27 | except EOFError:
28 |     pass
```