

Contents

1	Data Structure	1
1.1	Binary Search	1
1.2	BIT	1
1.3	Segment tree	1
1.4	Trie	1
1.5	BWT	2
2	Divide and Conquer	2
2.1	count inversions	2
3	DP	2
3.1	Doubling	2
3.2	Josephus	2
3.3	LCS	2
3.4	LIS	2
4	Enumerate	2
4.1	Halfcut Enumerate	2
5	Graph	3
5.1	SPFA	3
5.2	Dijkstra	3
5.3	Floyd Warshall	3
5.4	Disjoint set Kruskal	3
5.5	KM	4
5.6	Dinic	4
5.7	Bipartite	5
5.8	Hungarian algorithm	5
5.9	LCA	6
6	Other	6
6.1	Bubble Sort Expect Value	6
6.2	ORXOR	6
6.3	Race to 1	6
6.4	X drawing	7
6.5	Big Mod	7
6.6	Crested Ibis vs Monster	7
6.7	dpd Knapsack 1	7
6.8	Fraction Floor Sum	7
6.9	Homer Simpson	7
6.10	Let Me Count The Ways	8
6.11	Luggage	8
6.12	Number of Pairs	8
6.13	SuperSale	8
6.14	Walking on the Safe Side	8
6.15	Cutting Sticks	9
6.16	Partitioning by Palindromes	9
6.17	Ants Colony	9
6.18	Fill the Containers	10
6.19	How Many 0's	10
6.20	Binary codes	10
7	Function	10
7.1	strstr	10
7.2	substr	11
7.3	map set	11
7.4	vector	11
7.5	setprecision	11
7.6	GCD LCM	11
7.7	reverse	11
7.8	CHAR	11
7.9	sort	11
7.10	struct	11
7.11	deque	11
7.12	python template	12

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);

```

```

10 }
11 }

```

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    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         for(int i = 0; i < n; ++i)
7             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 }

```

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] = N;
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         } 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 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 }

```

```

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 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    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 };

```

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         }
25         else{
26             parent[b] = parent[a];
27         }
28     }
29 }

```

```

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         // 若都會產生環 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 void relax(int x){ // relaxation
13     for (int y=0; y<Y; ++y)
14         if (adj[x][y] != 1e9)
15             if (lx[x] + ly[y] - adj[x][y] < dy[y]){
16                 dy[y] = lx[x] + ly[y] - adj[x][y];
17                 pdy[y] = x; //
18                 // 記錄好是從哪個樹葉連出去的
19             }
20 }
21 void reweight(){ // 調整權重、調整表格
22     int d = 1e9;
23     for (int y=0; y<Y; ++y) if (!vy[y]) d = min(d, dy[y]);
24     for (int x=0; x<X; ++x) if (vx[x]) lx[x] -= d;
25     for (int y=0; y<Y; ++y) if (vy[y]) ly[y] += d;
26     for (int y=0; y<Y; ++y) if (!vy[y]) dy[y] -= d;
27 }
28 void augment(int x, int y){ // 擴充路徑
29     for (int ty; x != -1; x = p[x], y = ty){
30         ty = mx[x]; my[y] = x; mx[x] = y;
31     }
32 }
33 bool branch1(){ // 延展交錯樹：使用既有的等邊
34     while (qf < qb)
35         for (int x=*qf++, y=0; y<Y; ++y)
36             if (!vy[y] && lx[x] + ly[y] == adj[x][y]){
37                 vy[y] = true;
38                 if (my[y] == -1){
39                     augment(x, y);
40                     return true;
41                 }
42                 int z = my[y];
43                 *qb++ = z; p[z] = x; vx[z] = true;
44                 relax(z);
45             }
46     return false;

```

```

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

```

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){ //
    求出一條最短擴充路徑，並擴充流量
36 if (a == t) return df;
37 if (visit[a]) return 0;
38 visit[a] = true;
39 for (int i = adj[a]; i != -1; i = e[i].next){
40     int b = e[i].b;
41     if (e[i].r > 0 && d[a] + 1 == d[b]){
42         int f = DFS(b, min(df, e[i].r), s, t);
43         if (f){
44             e[i].r -= f;
45             e[i^1].r += f;
46             return f;
47         }
48     }
49 }
50 return 0;
51 }
52 int dinitz(int s, int t){
53     int flow = 0;
54     while (BFS(s, t) < V)
55         while (true){
56             memset(visit, false, sizeof(visit));
57             int f = DFS(s, 1e9, s, t);
58             if (!f) break;
59             flow += f;
60         }
61     return flow;
62 }

```

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 ==
        girl.music && boy.sport != girl.sport) return
        true;
17     return false;
18 }
19 bool dfs(int s){
20     for(int i = 0; i < G[s].size(); ++i){
21         int v = G[s][i];
22         if(visited[v]) continue;
23         visited[v] = true;
24         if(match[v] == -1 || dfs(match[v])){
25             match[v] = s;
26             return true;
27         }
28     }
29     return false;
30 }
31 int Hungarian(){
32     int cnt = 0;
33     memset(match, -1, sizeof(match));
34     for(int i = 0; i < bn; ++i){
35         memset(visited, false, sizeof(visited));
36         if(dfs(i)) cnt++;
37     }
38     return cnt;
39 }
40 int main(){
41     cin >> t;
42     while(t--){
43         cin >> N;
44         bn = 0, gn = 0;
45         for(int i = 0; i <= N; ++i) G[i].clear();
46         int h;
47         string sex, music, sport;
48         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 }

```

6 Other

6.1 Bubble Sort Expect Value

```

1  /* 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 ) << "/" << endl;
18     }
19     else{
20         cout << ( (n * (n - 1)) / 2 ) / 2 << endl;
21     }
22 }

```

6.2 ORXOR

```

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

```

6.3 Race to 1

```

1  const int N = 1000000;
2  bool sieve[N+5];
3  vector<int> pri;
4  double dp[N+5];
5  void Linear_Sieve(){ // 線性篩
6      for (int i = 2; i < N; i++){
7          if (!sieve[i])
8              pri.push_back(i);
9          for (int p: pri){
10             if (i * p >= N){
11                 break;
12             }
13             sieve[i * p] = true;
14             if (i % p == 0){
15                 break;
16             }
17         }
18     }
19 }
20 double dfs(int n){
21     if(dp[n] != -1) return dp[n];
22     dp[n] = 0;
23     if(n == 1) return dp[n];
24     int total = 0, prime = 0;
25     for(int i = 0; i < pri.size() && pri[i] <= n; i++){
26         total++;
27         if(n % pri[i]) continue;

```

```

28     prime++;
29     dp[n] += dfs(n/pri[i]);
30 }
31 dp[n] = (dp[n] + total)/prime; // 算期望值
32 return dp[n];
33 }
34 int main(){
35     int t;
36     int num;
37     int ca = 1;
38     for(int i = 0; i <= N; i++){
39         dp[i] = -1;
40     }
41     Linear_Sieve();
42     cin >> t;
43     while(t--){
44         cin >> num;
45
46         cout << "Case " << ca++ << ": " << fixed <<
             setprecision(10) << dfs(num) << endl;
47     }
48 }

```

6.4 X drawing

```

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

```

6.5 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

```

6.6 Crested Ibis vs Monster

```

1 /* dp 背包 - 重量/價值/可重複使用
2 因為這題可以重複使用同一條魔法
3 所以可以這樣dp*/
4 int h, n;
5 cin >> h >> n;
6 for(int i = 1; i <= n; i++){
7     cin >> a[i] >> b[i];
8 }
9 memset(dp, 0x3f3f3f3f, sizeof(dp));
10 dp[0][0] = 0;
11 for(int i = 1; i <= n; i++){
12     for(int j = 0; j <= h; j++){

```

```

13         dp[i][j] = min(dp[i-1][j], dp[i][max(0, j -
14             a[i])] + b[i]);
15     }
16 }
17 cout << dp[n][h] << endl;

```

6.7 dpd Knapsack 1

```

1 // dp 背包 - 時間/數量/價值 - 第幾分鐘符合
2 int N, W;
3 cin >> N >> W;
4 int w[100000+5];
5 int v[100000+5];
6 for(int i = 0; i < N; i++){
7     cin >> w[i] >> v[i];
8 }
9 long long int dp[100000+5];
10 memset(dp, 0, sizeof(dp));
11 for(int i = 0; i < N; i++){
12     for(int j = W; j >= w[i]; j--){
13         dp[j] = max(dp[j], dp[j - w[i]] + v[i]);
14     }
15 }
16 cout << dp[W] << endl;

```

6.8 Fraction Floor Sum

```

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

```

6.9 Homer Simpson

```

1 // dp 背包 - 時間/數量 - 漢堡
2 int m, n, t;
3 while(cin >> m >> n >> t){
4     int dp[10000+5];
5     memset(dp, -1, sizeof(dp));
6     dp[0] = 0;
7     for(int i = m; i <= t; i++){
8         if(dp[i - m] != -1){
9             dp[i] = max(dp[i], dp[i - m] + 1);
10        }
11    }
12    for(int i = n; i <= t; i++){
13        if(dp[i - n] != -1){
14            dp[i] = max(dp[i], dp[i - n] + 1);
15        }
16    }
17    if(dp[t] == -1){ // 時間無法剛好吃滿的時候
18        for(int i = t; i >= 0; i--){
19            if(dp[i] != -1){
20                cout << dp[i] << " " << t - i << endl;
21                break;
22            }
23        }
24    }
25    else{
26        cout << dp[t] << endl;

```

```
27 }
28 }
```

6.10 Let Me Count The Ways

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

6.11 Luggage

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

6.12 Number of Pairs

```
1 /* upper_bound ex:
2 10 20 30 30 40 50
3 upper_bound for element 30 is at index 4
4 lower_bound ex:
```

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

6.13 SuperSale

```
1 // dp 背包 - 重量/價值/不可重複使用 - 舉重
2 int t;
3 cin >> t;
4 while(t--){
5     int n;
6     cin >> n;
7     for(int i = 0; i < n; i++){
8         cin >> edge[i].p >> edge[i].w;
9     }
10    int g, total = 0;
11    cin >> g;
12    for(int i = 0; i < g; i++){
13        int pw, dp[30+5];
14        cin >> pw;
15        memset(dp, 0, sizeof(dp));
16        for(int j = 0; j < n; j++){
17            for(int k = pw; k >= edge[j].w; k--){
18                dp[k] = max(dp[k], dp[k - edge[j].w]
19                    + edge[j].p);
20            }
21        }
22        total += dp[pw];
23    }
24    cout << total << endl;
25 }
```

6.14 Walking on the Safe Side

```
1 // dp - 地圖更新
2 int t;
3 bool space = false;
4 cin >> t;
5 while(t--){
6     if(space){
7         cout << endl;
8     }
9     else{
10        space = true;
11    }
12    int r, c;
13    cin >> r >> c;
14    cin.ignore();
15    memset(mp, false, sizeof(mp));
16    memset(dp, 0, sizeof(dp));
17    string str;
18    for(int i = 0; i < r; i++){
19        getline(cin, str);
```



```

20     int n, num;
21     stringstream ss(str);
22     ss >> n;
23     while(ss >> num){
24         mp[n][num] = true;
25     }
26 }
27 dp[1][1] = 1;
28 for(int i = 1; i <= r; i++){
29     for(int j = 1; j <= c; j++){
30         if(mp[i][j]){
31             continue;
32         }
33         if(i > 1){
34             dp[i][j] += dp[i-1][j];
35         }
36         if(j > 1){
37             dp[i][j] += dp[i][j-1];
38         }
39     }
40 }
41 cout << dp[r][c] << endl;
42 }

```

6.15 Cutting Sticks

```

1 while(cin >> l && l){
2     cin >> n;
3     vector<int> s(n+2);
4     s[0] = 0;
5     for(int i = 1; i <= n; ++i) cin >> s[i];
6     s[++n] = 1; // 從現在開始 n 的數量變為 n + 1
7     int dp[n+5][n+5];
8     memset(dp, 0, sizeof(dp));
9     for(int r = 2; r <= n; ++r){ // r: 切幾段 b: 起點
10         // c: 中間點 e: 終點
11         for(int b = 0; b < n; ++b){
12             if(b + r > n) break;
13             int e = b + r;
14             dp[b][e] = 0x3f3f3f3f;
15             for(int c = b + 1; c < e; ++c){
16                 dp[b][e] = min(dp[b][e], dp[b][c] +
17                                 dp[c][e] + s[e] - s[b]);
18             }
19         }
20     }
21     cout << "The minimum cutting is " << dp[0][n] <<
22     "." << endl;
23 }

```

6.16 Partitioning by Palindromes

```

1 /*string & dp - 字串長度判斷迴文*/
2 bool check_palindromes(int lef, int rig){
3     // 比較字串兩端都是迴文
4     while(lef < rig){
5         if(str[lef] != str[rig]) return 0;
6         lef++;
7         rig--;
8     }
9     return 1;
10 }
11 int main(){
12     int t;
13     cin >> t;
14     while(t--){
15         cin >> str;
16         memset(dp, 0x3f3f3f3f, sizeof(dp));
17         dp[0] = 0;
18         for(int i = 0; i < str.size(); ++i)
19             for(int j = 0; j <= i; ++j)
20                 if(str[i] == str[j])
21                     if(check_palindromes(j, i))

```

```

22         if(dp[i+1] > dp[j] + 1)
23             dp[i+1] = dp[j] + 1;
24         cout << dp[str.size()] << endl;
25     }
26 }

```

6.17 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 下有幾顆 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] =
30                 parent[parent[j][i-1]][i-1];
31         }
32     }
33     // 求兩點的LCA (利用倍增法)
34     int LCA(int a, int b){
35         if(depth[b] < depth[a]) swap(a, b);
36         if(depth[a] != depth[b]){
37             int dif = depth[b] - depth[a];
38             for(int i = 0; i < 20; i++){
39                 if(dif & 1) b = parent[b][i];
40                 dif >>= 1;
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     }
52     long long int dist[maxn];
53     // 從 0 開始到每個點的距離
54     void distance(){
55         for(int u = 0; u < N; ++u){
56             for(int i = 0; i < G[u].size(); ++i){
57                 dist[G[u][i].v] = dist[u] + G[u][i].w;
58             }
59         }
60     }
61     int main(){
62         while(cin >> N && N){
63             memset(dist, 0, sizeof(dist));
64             memset(parent, 0, sizeof(parent));
65             memset(depth, 0, sizeof(depth));
66             memset(siz, 0, sizeof(siz));
67             for(int i = 0; i <= N; ++i){
68                 G[i].clear();
69             }
70             for(int i = 1; i < N; ++i){

```

```

67     int u, w;
68     cin >> u >> w;
69     G[u].push_back({i, w});
70     parent[i][0] = u;
71 }
72 find_parent();
73 dfs(0, 0);
74 distance();
75 int s; cin >> s;
76 bool space = false;
77 for(int i = 0; i < s; ++i){
78     int a, b;
79     cin >> a >> b;
80     int lca = LCA(a, b);
81     if(space) cout << " ";
82     space = true;
83     cout << (dist[a] + dist[b]) - (dist[lca]
84         * 2);
85 }
86 cout << endl;
87 }

```

6.18 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){
35             cin >> arr[i];
36             sum += arr[i];
37             maxi = max(maxi, arr[i]);
38         }
39         cout << binary_search(arr, maxi, sum, maxi)
40             << endl;
41     }
42 }

```

6.19 How Many 0's

```

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             ten *= 10;
31         }
32         if(n == 0) total1--;
33         cout << total2 - total1 << endl;
34     }
35 }

```

6.20 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         }
12         int ptr = mini[0];
13         for(int i = 0; i < n; ++i){
14             cout << back[ptr] << " ";
15             ptr = mini[ptr];
16         }
17         cout << endl;
18     }
19 }
20 int main(){
21     cin >> n;
22     for(int i = 0; i < n; ++i){
23         cin >> back[i];
24     }
25     zero = 0;
26     BWT();
27 }

```

7 Function

7.1 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

```

7.2 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 }

```

7.3 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，
13 // 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;

```

7.4 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

```

7.5 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

```

7.6 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 );

```

7.7 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

```

7.8 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
7 // space 和 \t
8 toupper()
9 tolower()

```

7.9 sort

```

1 priority_queue<int, vector<int>, less<int>> //大到小
2 priority_queue<int, vector<int>, greater<int>> //小到大
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

```

7.10 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 };

```

7.11 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) <<
9     endl;

```

7.12 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
```