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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 #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 }

```

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         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    }

```

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++];

```

```

11     else{
12         if(arr[i] <= arr[j]) buf[k] = arr[i++];
13         else{
14             buf[k] = arr[j++];
15             ans += mid - i;
16         }
17     }
18     k++;
19 }
20 for(int k = lef; k < rig; ++k) arr[k] = buf[k];
21 return ans;
22 }

```

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  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 }

```

4.3 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 }

```

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;
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 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 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 }

```

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
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 }

```

6.5 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         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         isBipartite();
44     }
45 }

```

6.6 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 ==
18         girl.music && boy.sport != girl.sport) return
19         true;
20     return false;
21 }
22 bool dfs(int s){
23     for(int i = 0; i < G[s].size(); ++i){
24         int v = G[s][i];
25         if(visited[v]) continue;
26         visited[v] = true;
27         if(match[v] == -1 || dfs(match[v])){
28             match[v] = s;
29             return true;
30         }
31     }
32     return false;
33 }
34 int Hungarian(){
35     int cnt = 0;
36     memset(match, -1, sizeof(match));
37     for(int i = 0; i < bn; ++i){
38         memset(visited, false, sizeof(visited));
39         if(dfs(i)) cnt++;
40     }
41     return cnt;
42 }
43 int main(){
44     cin >> t;
45     while(t--){
46         cin >> N;
47         bn = 0, gn = 0;
48         for(int i = 0; i <= N; ++i) G[i].clear();
49         int h;
50         string sex, music, sport;
51         for(int i = 0; i < N; ++i){
52             cin >> h >> sex >> music >> sport;
53             if(sex == "M") lef[bn++] = People(h,
54                 music, sport);
55             else rig[gn++] = People(h, music, sport);

```

```

53     }
54     for(int i = 0; i < bn; ++i){
55         for(int j = 0; j < gn; ++j)
56             if(check(lef[i], rig[j]))
57                 G[i].emplace_back(j);
58     }
59     cout << N - Hungarian() << endl;
60 }

```

6.7 LCA

```

1  /*最低共同祖先*/
2  // 此 node 下有幾顆 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 // 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];

```

7 Other

7.1 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] =
                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     }
}

```

7.2 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         zero = 0;
24         BWT();
25     }
}

```

7.3 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     }
}

```

8 DP

8.1 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 3 6
7  0 2 2 2 2 3 3 3 3 5
8  0 1 1 2 2 3 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     memset(dp, 0x3f3f3f3f, sizeof(dp));
19     dp[0][0] = 0;
20     for(int i = 1; i <= n; i++)
21         for(int j = 0; j <= h; j++)
22             dp[i][j] = min(dp[i-1][j], dp[i][max(0, j
23                 - a[i])]) + b[i]);
24     cout << dp[n][h] << endl;

```

8.2 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[100000+5], v[100000+5];
14     for(int i = 0; i < N; i++)
15         cin >> w[i] >> v[i];
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     cout << dp[W] << endl;

```

8.3 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*/

```

```

9  int main(){
10     int m, n, t;
11     while(cin >> m >> n >> t){
12         int dp[10000+5];
13         memset(dp, -1, sizeof(dp));
14         dp[0] = 0;
15         for(int i = m; i <= t; i++)
16             if(dp[i - m] != -1)
17                 dp[i] = max(dp[i], dp[i - m] + 1);
18         for(int i = n; i <= t; i++)
19             if(dp[i - n] != -1)
20                 dp[i] = max(dp[i], dp[i - n] + 1);
21         // 時間無法剛好吃滿的時候
22         if(dp[t] == -1){
23             for(int i = t; i >= 0; i--){
24                 if(dp[i] != -1){
25                     cout << dp[i] << " " << t - i <<
26                         endl;
27                     break;
28                 }
29             }
30             else cout << dp[t] << endl;
31         }

```

8.4 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 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     }

```

8.5 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  1
5  Note: dp[0] = true */
6  int main(){
7     int t;
8     cin >> t;
9     cin.ignore();
10     while(t--){
11         string str;
12         getline(cin, str);
13         vector<int> v;
14         stringstream ss;
15         int num, cnt = 0, sum = 0;
16         bool dp[4000+5];
17         memset(dp, false, sizeof(dp));
18         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         }
33     }
34     cout << (dp[sum/2] ? "YES" : "NO") << endl;
35 }

```

8.6 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] = 0xf3f3f3f
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, 0xf3f3f3f, 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 }

```

8.7 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         }
22         int g, total = 0;
23         cin >> g;
24         for(int i = 0; i < g; i++){
25             int pw; cin >> pw;
26             int dp[30+5];
27             memset(dp, 0, sizeof(dp));
28             for(int j = 0; j < n; j++){
29                 for(int k = pw; k >= edge[j].w; k--){
30                     dp[k] = max(dp[k], dp[k -
31                         edge[j].w] + edge[j].p);
32                 }
33             }
34             total += dp[pw];
35         }
36         cout << total << endl;
37     }
38 }

```

8.8 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 }

```

8.9 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] = 1;
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;
46     }
47 }

```

8.10 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 Math

9.1 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

```

9.2 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 << endl;
22     }
23 }

```


9.3 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 }

```

9.4 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) %
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 }

```

9.5 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 }

```

9.6 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++){
33                 OR |= num[j];
34                 if((i & (1 << j))){
35                     XOR ^= OR;
36                     OR = 0;
37                 }
38             }
39             XOR ^= OR;
40             mini = min(mini, XOR);
41         }
42         cout << mini << endl;
43     }
44 }

```

9.7 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 }

```

```

15   if(lef == rig) cout << marble << " not
16       found" << endl;
17   else{
18       cout << marble << " found at " << lef
19           + 1 << endl;
20   }
21 }

```

10 Binary Search

10.1 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         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     }

```

10.2 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();

```

11 Segement Tree

11.1 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 segement 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         // 更新左邊界至被切區塊的右邊界加一，就不會切到區塊
44         lef = num[lef].rig + 1;
45     }
46     // 查詢的右區間邊界切到區塊，且此區間有數個區塊
47     if(rig < num[rig].rig){
48         // 計算切到的區間大小，並找出最大
49         ans = max(ans, rig - num[rig].lef + 1);
50         // 更新右邊界
51         rig = num[rig].lef - 1;
52     }
53     // 如果左邊界大於右邊界，表示不需要再進行查詢直接回傳答案
54     if(lef > rig) return ans;
55     if(tree[x].lef >= lef && tree[x].rig <= rig)
56         return tree[x].value;
57     int mid = (tree[x].lef + tree[x].rig) >> 1;

```

```

54     if(lef <= mid) ans = max(ans, query(lef, rig,
55         Lson(x)));
56     if(mid < rig) ans = max(ans, query(lef, rig,
57         Rson(x)));
58     return ans;
59 }
60 int main(){
61     int n, q;
62     while(cin >> n && n){
63         cin >> q;
64         int start = 1;
65         for(int i = 1; i <= n; ++i){
66             cin >> num[i].value;
67             if(num[i].value != num[i-1].value){
68                 for(int j = start; j < i; ++j){
69                     num[j].rig = i - 1;
70                     num[j].fre = i - start;
71                 }
72                 start = num[i].lef = i;
73             }
74             else num[i].lef = start;
75         }
76         // 最後一段 [start, n]
77         for(int j = start; j <= n; ++j){
78             num[j].rig = n;
79             num[j].fre = n - start + 1;
80         }
81         build(1, n, 1);
82         int lef, rig;
83         for(int i = 0; i < q; ++i){
84             cin >> lef >> rig;
85             cout << query(lef, rig, 1) << endl;
86         }
87     }
88 }

```

12 Bipartite Graph

12.1 Claw Decomposition

```

1  /*二分圖 Bipatirate*/
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
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     return true;
21 }
22 void isBipatirate(){
23     bool flag = true;
24     for(int i = 1; i <= n; ++i){
25         if(color[i] == -1){
26             // 如果還未填色過，就先填色成
27             // 1，並對與此點相連的點都 dfs 判定填色
28             color[i] = 1;
29             flag &= dfs(i);
30         }
31     }
32     if(flag) cout << "YES" << endl;
33     else cout << "NO" << endl;
34 }

```

```

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 }

```

12.2 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;
58         string sex, music, sport;
59         for(int i = 0; i < N; ++i){
60             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 }

```

13 Function

13.1 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()

```

13.2 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 }

```

13.3 setprecision

```

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

```

13.4 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 }

```

```

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 );

```

13.5 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

```

13.6 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

```

13.7 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        cout<<"Do not Find"<<endl;
26
27    mp.clear();
28    mp.erase(mp.begin(), mp.end());
29 }

```

13.8 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 | }
```