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## 1 Basic

### 1.1 BIT

```

1 #define lowbit(k) (k & -k)
2
3 int n;
4 vector<int> B1, B2;
5
6 void add(vector<int> &tr, int id, int val) {
7     for (; id <= n; id += lowbit(id)) {
8         tr[id] += val;
9     }
10 }
11 void range_add(int l, int r, int val) {
12     add(B1, l, val);
13     add(B1, r + 1, -val);
14     add(B2, l, val * (1 - 1));
15     add(B2, r + 1, -val * r);
16 }
17 int sum(vector<int> &tr, int id) {
18     int ret = 0;
19     for (; id >= 1; id -= lowbit(id)) {
20         ret += tr[id];
21     }
22     return ret;
23 }
24 int prefix_sum(int id) {
25     return sum(B1, id) * id - sum(B2, id);
26 }
27 int range_sum(int l, int r) {
28     return prefix_sum(r) - prefix_sum(l - 1);
29 }

```

### 1.2 Black Magic

```

1 #include <bits/extc++.h>
2 // #include <ext/pb_ds/assoc_container.hpp>
3 // #include <ext/pb_ds/tree_policy.hpp>
4 // #include <ext/pb_ds/priority_queue.hpp>
5 using namespace std;
6 using namespace __gnu_pbds;
7 using set_t =
8     tree<int, null_type, less<int>, rb_tree_tag,
9     tree_order_statistics_node_update>; //紅黑樹(set)
10 using map_t =
11     tree<int, int, less<int>, rb_tree_tag,
12     tree_order_statistics_node_update>; //紅黑樹(map)
13 using heap_t =
14     __gnu_pbds::priority_queue<int>;
15 using ht_t =

```

```

16 gp_hash_table<int, int>;
17 int main() {
18     //set-----
19     set_t st;
20     st.insert(5); st.insert(6);
21     st.insert(3); st.insert(1);
22
23     // the smallest is (0), biggest is (n-1), kth small
24     // is (k-1)
25     int num = *st.find_by_order(0);
26     cout << num << '\n'; // print 1
27
28     num = *st.find_by_order(st.size() - 1);
29     cout << num << '\n'; // print 6
30
31     // find the index
32     int index = st.order_of_key(6); //在裡面第幾大
33     cout << index << '\n'; // print 3
34
35     // check if there exists x
36     int x = 5;
37     int check = st.erase(x);
38     if (check == 0) printf("st not contain 5\n");
39     else if (check == 1) printf("st contain 5\n");
40
41     //tree policy like set
42     st.insert(5); st.insert(5);
43     cout << st.size() << '\n'; // print 4
44
45     //map-----
46     map_t mp;
47     mp[1] = 2;
48     cout << mp[1] << '\n';
49     auto tmp = *mp.find_by_order(0); // pair
50     cout << tmp.first << " " << tmp.second << '\n';
51
52     //heap-----
53     heap_t h1, h2;
54     h1.push(1); h1.push(3);
55     h2.push(2); h2.push(4);
56     h1.join(h2);
57     cout << h1.size() << h2.size() << h1.top() << '\n';
58     // 支援合併
59     // 404
60
61     //hash-table-----
62     ht_t ht;
63     ht[85] = 5;
64     ht[89975] = 234;
65     for (auto i : ht) {
66         cout << i.first << " " << i.second << '\n';
67     }
68     //比較強的unordered map

```

### 1.3 DJS

```

1 const int MAXN = 1000;
2 int boss[MAXN];
3 void init(int n) {
4     for (int i = 0; i < n; i++) {
5         boss[i] = -1;
6     }
7 }
8 int find(int x) {
9     if (boss[x] < 0) {
10         return x;
11     }
12     return boss[x] = find(boss[x]);
13 }
14 bool uni(int a, int b) {
15     a = find(a);
16     b = find(b);
17     if (a == b) {
18         return false;

```

```

19 }
20 if (boss[a] > boss[b]) {
21     swap(a, b);
22 }
23 boss[a] += boss[b];
24 boss[b] = a;
25 return true;
26 }

```

```

5     s.push_back(a[i]);
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 }

```

## 1.4 ST

```

1 const int INF = 1e9;
2 const int MAXN = ;
3
4 int n;
5 int a[MAXN], tr[MAXN << 1];
6
7 // !!! remember to call this function
8 void build() {
9     for (int i = 0; i < n; i++) {
10         tr[i + n] = a[i];
11     }
12     for (int i = n - 1; i > 0; i--) {
13         tr[i] = max(tr[i << 1], tr[i << 1 | 1]);
14     }
15 }
16 void update(int id, int val) {
17     for (tr[id += n] = val; id > 1; id >>= 1) {
18         tr[id >> 1] = max(tr[id], tr[id ^ 1]);
19     }
20 }
21 int query(int l, int r) { // [l, r)
22     int ret = -INF;
23     for (l += n, r += n; l < r; l >>= 1, r >>= 1) {
24         if (l & 1) {
25             ret = max(ret, tr[l++]);
26         }
27         if (r & 1) {
28             ret = max(ret, tr[--r]);
29         }
30     }
31     return ret;
32 }

```

## 2 DP

### 2.1 LCS

```

1 int LCS(string s1, string s2) {
2     int n1 = s1.size(), n2 = s2.size();
3     vector<vector<int>> dp(n1 + 1, vector<int>(n2 + 1,
4         0));
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 }

```

### 2.2 LIS

```

1 int LIS(vector<int> &a) {
2     vector<int> s;
3     for (int i = 0; i < a.size(); i++) {
4         if (s.empty() || s.back() < a[i]) {

```

## 2.3 迴文

```

1 bool isPalindrome[100][100];
2 // Find the palindromes of a string in O(n^2)
3
4 int main()
5 {
6     ios_base::sync_with_stdio(0);
7     // freopen("in.txt", "r", stdin);
8     string s;
9     cin >> s;
10    int len = s.size();
11    for (int i = 0; i < len; i++)
12        isPalindrome[i][i] = true;
13
14    for (int k = 1; k < len; k++) {
15        for (int i = 0; i + k < len; i++) {
16            int j = i + k;
17            isPalindrome[i][j] = (s[i] == s[j]) &&
18                (isPalindrome[i + 1][j - 1] || i + 1 == j - 1);
19        }
20    }
21    return 0;
22 }

```

## 3 Basic

### 3.1 bellman ford

```

1 bool bellman(int src)
2 {
3     // Nodes are indexed from 1
4     for (int i = 1; i <= n; i++)
5         dist[i] = INF;
6     dist[src] = 0;
7     for (int i = 2; i <= n; i++)
8     {
9         for (int j = 0; j < edges.size(); j++)
10         {
11             int u = edges[j].first;
12             int v = edges[j].second;
13             ll weight = adj[u][v];
14             if (dist[u] != INF && dist[u] + weight <
15                 dist[v])
16                 dist[v] = dist[u] + weight;
17         }
18     }
19     for (int i = 0; i < edges.size(); i++)
20     {
21         int u = edges[i].first;
22         int v = edges[i].second;
23         ll weight = adj[u][v];
24         // True if neg-cycle exists
25         if (dist[u] != INF && dist[u] + weight < dist[v])
26             return true;
27     }
28     return false;
29 }

```

### 3.2 Dijk

```

1 | const long long int INF = 1e18;
2 | const int MAXN = 1000000;
3 | struct Edge {
4 |     int to;
5 |     long long int cost;
6 |     Edge(int v, long long int c) : to(v), cost(c) {}
7 |     bool operator < (const Edge &other) const {
8 |         return cost > other.cost;
9 |     }
10 | };
11 |
12 | int n;
13 | long long int dis[MAXN];
14 | vector<Edge> G[MAXN];
15 |
16 | void init() {
17 |     for (int i = 0; i < n; i++) {
18 |         G[i].clear();
19 |         dis[i] = INF;
20 |     }
21 | }
22 | void Dijkstra(int st, int ed = -1) {
23 |     priority_queue<Edge> pq;
24 |     pq.emplace(st, 0);
25 |     dis[st] = 0;
26 |     while (!pq.empty()) {
27 |         auto now = pq.top();
28 |         pq.pop();
29 |         if (now.to == ed) {
30 |             return;
31 |         }
32 |         if (now.cost > dis[now.to]) {
33 |             continue;
34 |         }
35 |         for (auto &e : G[now.to]) {
36 |             if (dis[e.to] > now.cost + e.cost) {
37 |                 dis[e.to] = now.cost + e.cost;
38 |                 pq.emplace(e.to, dis[e.to]);
39 |             }
40 |         }
41 |     }
42 | }

```

### 3.3 edges

```

1 | struct Edge
2 | {
3 |     int from, to, w;
4 |     bool operator<(const Edge& rhs) // optional
5 |     {
6 |         return w < rhs.w;
7 |     }
8 | };

```

### 3.4 floyd

```

1 | const LL INF = 1e18;
2 | const int MAXN = ;
3 |
4 | int n;
5 | LL G[MAXN][MAXN];
6 |
7 | void init() {
8 |     for (int i = 0; i < n; i++) {
9 |         for (int j = 0; j < n; j++) {
10 |             G[i][j] = INF;
11 |         }
12 |         G[i][i] = 0;
13 |     }
14 | }
15 | void floyd() {
16 |     for (int k = 0; k < n; k++) {
17 |         for (int i = 0; i < n; i++) {

```

```

18 |             for (int j = 0; j < n; j++) {
19 |                 if (G[i][k] != INF && G[k][j] != INF) {
20 |                     G[i][j] = min(G[i][j], G[i][k] + G[k][j]);
21 |                 }
22 |             }
23 |         }
24 |     }
25 | }

```

## 4 Math

### 4.1 GCDhjackh

```

1 | int extgcd(int a, int b, int c, int &x, int &y) {
2 |     if (b == 0) {
3 |         x = c / a;
4 |         y = 0;
5 |         return a;
6 |     }
7 |     int d = extgcd(b, a % b, c, x, y);
8 |     int tmp = x;
9 |     x = y;
10 |    y = tmp - (a / b) * y;
11 |    return d;
12 | }

```

### 4.2 Prime

```

1 | const int maxn = ;
2 | int arr[maxn];
3 | int prime[maxn];
4 | void init(){
5 |     for (int i = 0; i < maxn; ++i){
6 |         arr[i] = 0;
7 |     }
8 | }
9 | void find(){
10 |    int num = 0;
11 |    for(int i = 2;i<maxn;i++){
12 |        if(arr[i] == 0){
13 |            prime[num] = i;
14 |            num++;
15 |            for(int j = i*i;j<maxn;j+=i){
16 |                arr[j] = 1;
17 |            }
18 |        }
19 |    }
20 | }

```

