

# Competitive Programming

Bjarki Ágúst Guðmundsson

Trausti Sæmundsson

Ingólfur Eðvarðsson

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## 1 Data Structures

### 1.1 Union-Find

```
1 void uf_init(int* arr, int n) {
2     for (int i = 0; i < n; i++) {
3         arr[i] = i;
4     }
5 }
6
7 int uf_find(int* arr, int i) {
8     return arr[i] == i ? i : (arr[i] = uf_find(arr, arr[i]));
9 }
10
11 void uf_union(int* arr, int i, int j) {
12     arr[uf_find(arr, i)] = uf_find(uf_find(arr, j));
13 }
```

### 1.2 Segment Tree

### 1.3 Fenwick Tree

### 1.4 Interval Tree

## 2 Graphs

### 2.1 Breadth-First Search

An example of a breadth-first search that counts the number of edges on the shortest path from the starting vertex to the ending vertex. Note that it assumes that the two vertices are connected.

```
1 int bfs(int start, int end, vector<vi> adj_list) {
2     queue<ii> Q;
3     Q.push(ii(start, 0));
4
5     while (true) {
6         ii cur = Q.top(); Q.pop();
7
8         if (cur.first == end) {
9             return cur.second;
10        }
11
12        vi& adj = adj_list[cur.first];
13        for (vi::iterator it = adj.begin(); it != adj.end(); it++) {
14            Q.push(ii(*it, cur.second + 1));
15        }
16    }
17 }
```

## 2.2 Depth-First Search

## 2.3 Single Source Shortest Path

### 2.3.1 Dijkstra's algorithm

```
1  #define MAXEDGES 20000
2  bool done[MAXEDGES];
3
4  int dijkstra(int start, int end, vvii& adj_list) {
5      memset(done, 0, MAXEDGES);
6      priority_queue<ii, vii, greater<ii> > pq;
7      pq.push(ii(0, start));
8
9      while (!pq.empty()) {
10         ii current = pq.top(); pq.pop();
11         done[current.second] = true;
12
13         if (current.second == end)
14             return current.first;
15
16         vii &vtmp = adj_list[current.second];
17         for (vii::iterator it=vtmp.begin(); it != vtmp.end(); it++)
18             if (!done[it->second])
19                 pq.push(ii(current.first + it->first,
20                             it->second));
21     }
22     return -1;
23 }
```

**2.3.2 Bellman-Ford algorithm****2.4 All Pairs Shortest Path****2.4.1 Floyd-Warshall algorithm****2.5 Connected Components****2.5.1 Modified Breadth-First Search****2.6 Strongly Connected Components****2.6.1 Kosaraju's algorithm****2.6.2 Tarjan's algorithm****2.7 Topological Sort****2.7.1 Modified Breadth-First Search****2.8 Articulation Points/Bridges****2.8.1 Modified Depth-First Search****3 Number Theory****3.1 Binomial Coefficients**

The binomial coefficient  $\binom{n}{k} = \frac{n!}{k!(n-k)!}$  is the number of ways to choose  $k$  items out of a total of  $n$  items.

```
1 int factorial(int n) {
2     int res = 1;
3     while (n) {
4         res *= n--;
5     }
6
7     return res;
8 }
9
10 int nck(int n, int k) {
11     return factorial(n) / factorial(k) / factorial(n - k);
12 }
13
14 void nck_precompute(int** arr, int n) {
15     for (int i = 0; i < n; i++)
16         arr[i][0] = arr[i][i] = 1;
17
18     for (int i = 1; i < n; i++)
19         for (int j = 1; j < i; j++)
20             arr[i][j] = arr[i - 1][j - 1] + arr[i - 1][j];
21 }
```

```
1 int nck(int n, int k) {
2     if (n - k < k)
3         k = n - k;
4
5     int res = 1;
6     for (int i = 1; i <= k; i++)
7         res = res * (n - (k - i)) / i;
8
9     return res;
10 }
```