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2.1 DFS

$O(n+m)$

```
void dfs(ll at, ll n ,vpll adj[], bool visited[]) {
    if(visited[at])
        return;

    visited[at] = true;

    vpll neighbours = adj[at];
    for(auto nex: neighbours)
        dfs(nex.first, n, adj, visited);
}
```

2.2 BFS

$O(n+m)$

```
void bfs(ll s, ll n, vll adj[]) {
    bool visited[n] = {0};
    visited[s] = true;

    queue<ll> q;
    q.push(s);
    while (!q.empty())
    {
        vll neighbours = adj[q.front()];
```

```
        for(auto nex: neighbours) {
            if(!visited[nex]) {
                visited[nex]=true;
                q.push(nex);
            }
        }
        cout << q.front() << '\n';
        q.pop();
    }
}
```

2.2.1 Shortest path on unweighted graph

$O(n+m)$

```
vll solve(ll s, ll n, vll adj[]) {
    bool visited[n] = {0};
    visited[s] = true;

    queue<ll> q;
    q.push(s);
    vll prev(n, -1);
    while (!q.empty())
    {
        vll neighbours = adj[q.front()];
        for(auto nex: neighbours) {
            if(!visited[nex]) {
                visited[nex]=true;
                q.push(nex);
                prev[nex] = q.front();
            }
        }
        q.pop();
    }

    return prev;
}

vll reconstructPath(ll s, ll e, vll prev) {
    vll path;
    for(ll i=e; i!=-1; i=prev[i])
        path.push_back(i);

    reverse(path.begin(), path.end());

    if(path[0]==s)
        return path;
    else {
        vll place;
```

```
        return place;
    }
}

vll bfs(ll s, ll e, ll n, vll adj[]) {
    vll prev = solve(s, n, adj);

    return reconstructPath(s, e, prev);
}
```

2.3 Flood Fill

$O(n+m)$

```
int dir_y[] = {};
int dir_x[] = {};

int ff(int i, int j, char c1, char c2) {
    if ((i < 0) || (i >= n)) return 0;
    if ((j < 0) || (j >= m)) return 0;
    if (grid[i][j] != c1) return 0;

    int ans = 1;
    grid[i][j] = c2;

    for (int d = 0; d < 8; ++d)
        ans += floodfill(i+dir_y[d], j+dir_x[d], c1, c2);

    return ans;
}
```

;

2.4 Topological Sort (Directed Acyclic Graph)

2.4.1 DFS Variation

$O(n+m)$

```
void dfs(ll at, ll n ,vpll adj[], bool visited[], vll &ts) {
    if(visited[at])
        return;

    visited[at] = true;

    vpll neighbours = adj[at];
    for(auto nex: neighbours)
        dfs(nex.first, n, adj, visited);
    ts.push_back(at);                          // Only change
}
```

2.4.2 Kahn's Algorithm

```
priority_queue<ll, vll, greater<ll>> pq;
for(ll at=0; at<n; at++)        // Push all sources of
    connected components in graph
    if(in_degree[at] == 0)
        pq.push(at);

while(!pq.empty()) {
    ll at = pq.top(); pq.pop();
    vll neighbors = adj[at];
    for(auto nex: neighbors) {
        in_degree[nex]--;
        if(in_degree[nex]>0) continue;
        pq.push(nex);
    }
}
```

2.5 Bipartite Graph Check (Undirected Graph)

$O(n+m)$

```
bool isBipartite(ll s, ll n, vll adj[]) {
    queue<ll> q;
    q.push(s);
    vll color(n, -1); color[s]=0;
    bool flag = true;
    while (!q.empty())
    {
        vll neighbours = adj[q.front()];
        for(auto nex: neighbours) {
            if(color[nex] == -1) {
                color[nex] = 1-(color[q.front()]);
                q.push(nex);
            }
            else if(color[nex] == color[q.front()]) {
                flag = false;
                break;
            }
        }
        q.pop();
    }

    return flag;
}
```

2.6 Cycle Check (Directed Graph)

$O(n+m)$

```
enum { UNVISITED = -1, VISITED = -2,  EXPLORED=-3};

void cycleCheck(ll at, ll n ,vll adj[], int visited[], ll
    dfs_parent[]) {
    visited[at] = EXPLORED;

    vll neighbours = adj[at];
    for(auto nex: neighbours) {
        if(visited[nex] == UNVISITED) {
            // Tree edges (part of the DFS spanning tree)
            dfs_parent[nex] = at;
            cycleCheck(nex, n, adj, visited);
        }
        else if(visited[nex] == EXPLORED) {
            if(nex == dfs_parent[at]) {
                // Trivial cycle
                // Do something
            }
            else {
                // Non trivial cycle - Back Edge ((u, v)
                    such that v is the ancestor of node u but
                     is not part of the DFS tree)
                // Do something
            }

        }
        else if(visited[nex] == VISITED) {
            // Forward/Cross edge ((u, v) such that v is a
                descendant but not part of the DFS tree)
            // Do something
        }

    }

    visited[at] = VISITED;
}
```