Congratulations for maintaining >80% PSP 🔥🥳

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Today's Content →

Introduction to Graphs

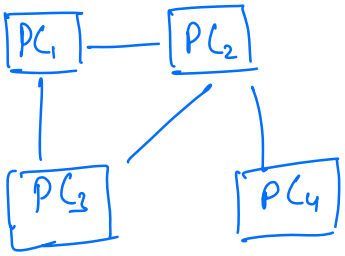
Types of Graphs

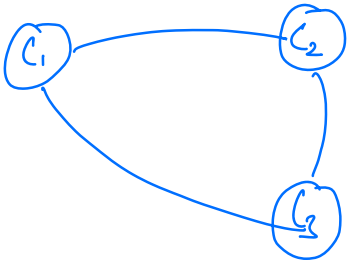
DFS

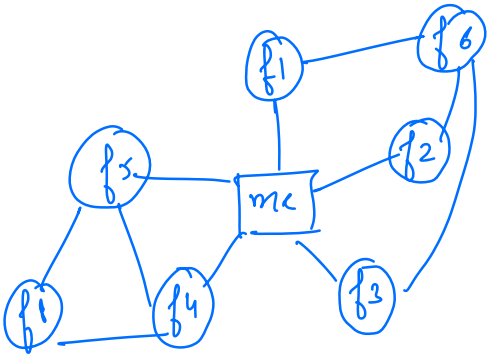
BFS

Detect cycle in directed graph.

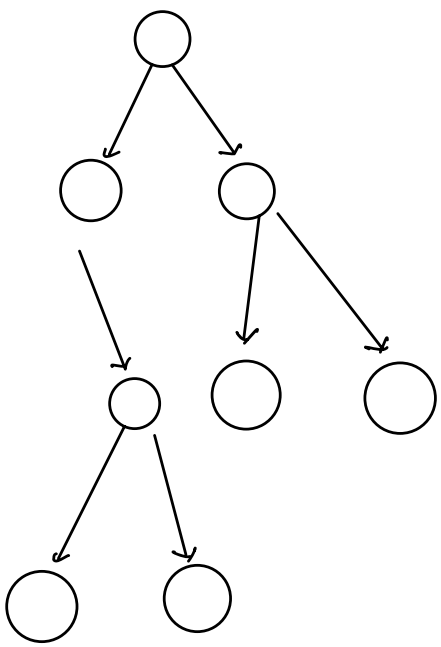
Graph → network.







graph → collection of nodes (or vertices) and edges.



① Tree always has root node.

② N nodes → N-1 edges.

③ Cycle can't be there in tree.

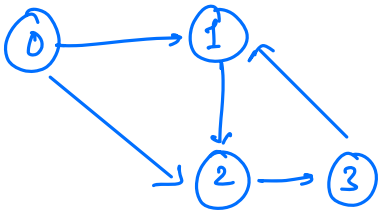
Every tree is a graph. ✓

Every graph is a tree. ✗

⇓

[Tree is a subset of Graph]

How to store graphs?



4 Nodes (N)
5 edges (E)

① Adjacency Matrix

	0	1	2	3
0	0	1	1	0
1	0	0	1	0
2	0	0	0	1
3	0	1	0	0

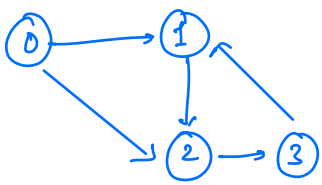
mat[i][j] = 0 ⇒ There is no edge from i to j.

mat[i][j] = 1 ⇒ There is an edge from i to j.

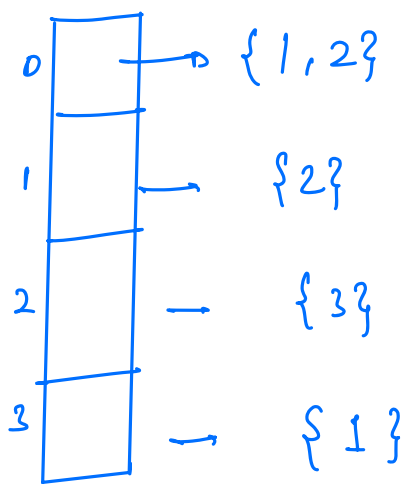
SC → $O(N^2)$

② Adjacency List

(Array of lists)



N = 4
E = 5



A[i] → adjacent nodes in the list
↳ neighbours of i in the list.

$\begin{bmatrix} 1 \le N \le 10^5 \\ 1 \le E \le 10^5 \end{bmatrix}$

SC → $O(N+E)$

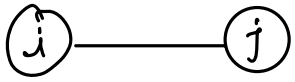
Properties / Types of Graph

① **Directed**

i to j ✓

j to i ✗

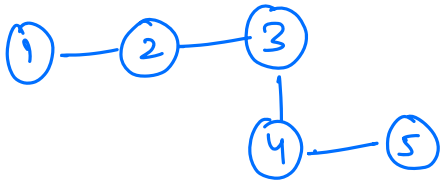
Un-directed Graph (Bi-directional)



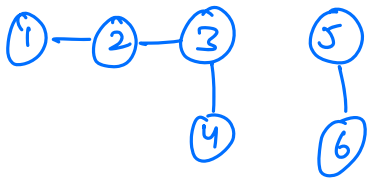
i to j ✓

j to i ✓

② **Connected**



Disconnected



③ **Weighted**

Un-weighted

mat[i][j] = 0 if there is no edge from i to j

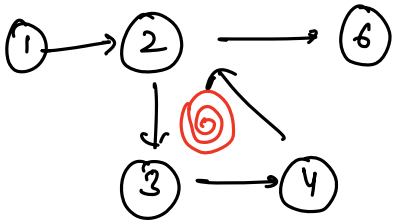
= W_{ij} if there is edge from i to j.

graph[i] = { {1, 5}, {2, 3}, {4, 7} - - }

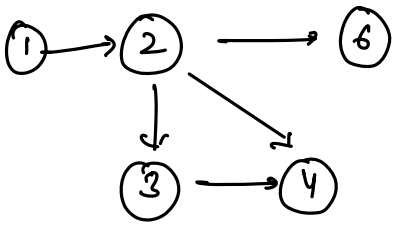
list of pairs

pair {
  vtx :
  edge wt ;
}

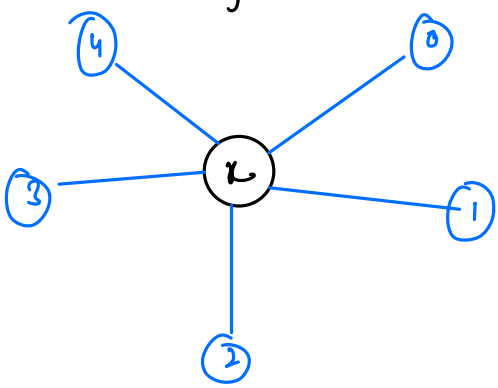
(4) Cyclic.



Acyclic



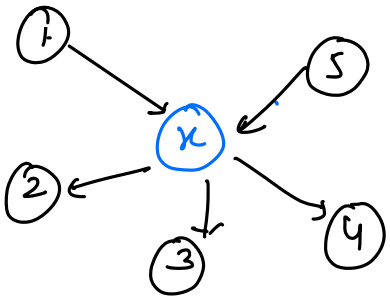
(5) Degree.



degree(x) = 5

No. of edges connected with a node.

In-degree / out-degree



in-degree(x) → incoming edges [2]

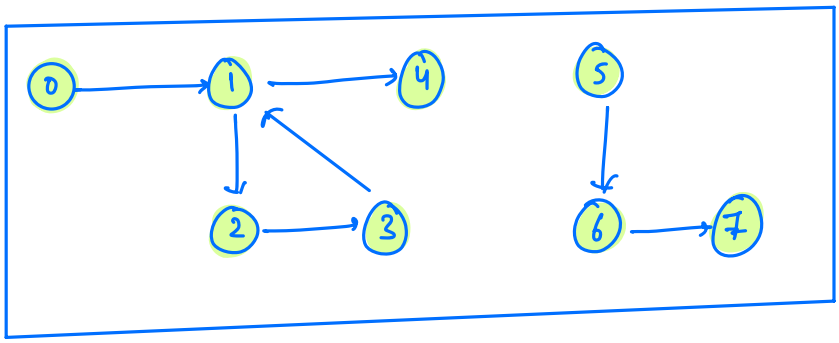
out-degree(x) → outgoing edges [3]

N nodes. → numbered from 0 to N-1

if they are not numbered from 0 to N-1, then we will do the mapping and get the order from 0 to N-1.

Traversals

① Depth First Traversal (Pre-order traversal of tree)

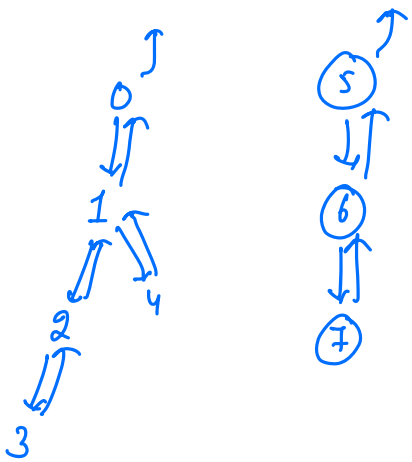


N = 8 , E = 7

→ Keep track of visited nodes.

visited →

t	t	t	t	t	t	t	t
0	1	2	3	4	5	6	7



code →

```
//Graph → given

boolean visited[N];   // ∀i, visited[i] = false

for( i=0; i<N; i++){
    if( visited[i] == false){
        dfs( graph, i, visited);
    }
}
```

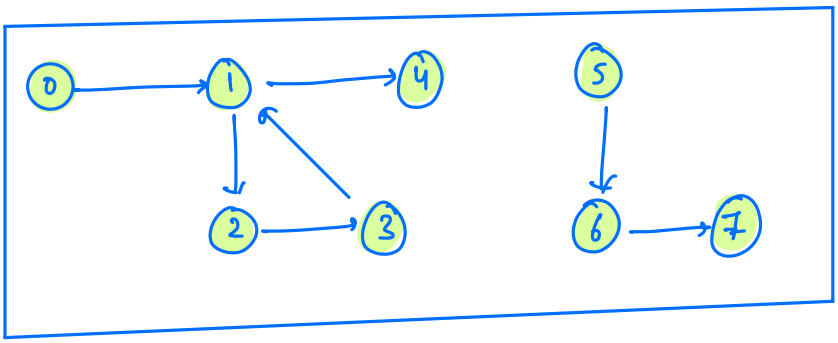
```
void dfs( Graph, src, visited[N]){
    print(src);
    visited[src] = true;
    for( int nbr : graph[src]){
        if( visited[nbr] == false){
            dfs( graph, nbr, visited);
        }
    }
}
```

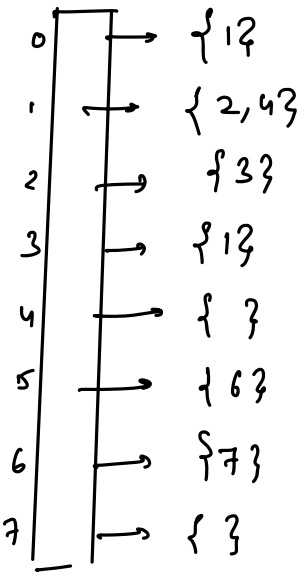
T.C → O(N+E)
S.C → O(N)

↓

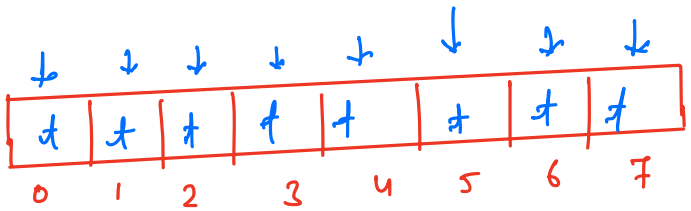
visited[N] + max size of stack.

Breadth First Traversal → level order traversal.

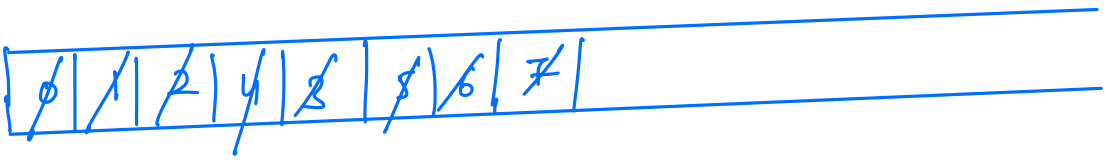




visited →



queue →



print → 0, 1, 2, 4, 3, 5, 6, 7

code →

```
//Graph → given

boolean visited[N];   // ∀i, visited[i] = false

for( i=0; i<N; i++){
    if( visited[i] == false){
        bfs( graph, i, visited);
    }
}
```

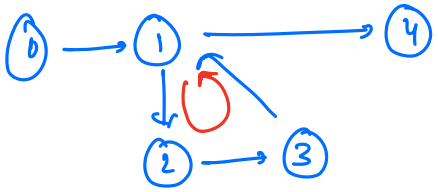
```
void bfs( graph, src, visited){
    Queue<int> q;
    q.enqueue(src), visited[src]= true;
    print(src);
    while( q.isEmpty() == false){
        vr = q.dequeue();
        for( int nbr : graph[vr]){
            if( visited[nbr] == false){
                visited[nbr] = true; print(nbr);
                q.enqueue( nbr);
            }
        }
    }
}
```

T.C → O(N+E)
S.C → O(N)

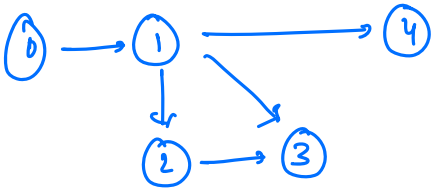
↓

visited [N],
Queue

Q Check if given directed graph has a cycle or not.



ans → true.



ans → false

→ if a visited node is encountered again → cycle. ✗

→ if a visited node in current path → cycle ✓
is encountered again

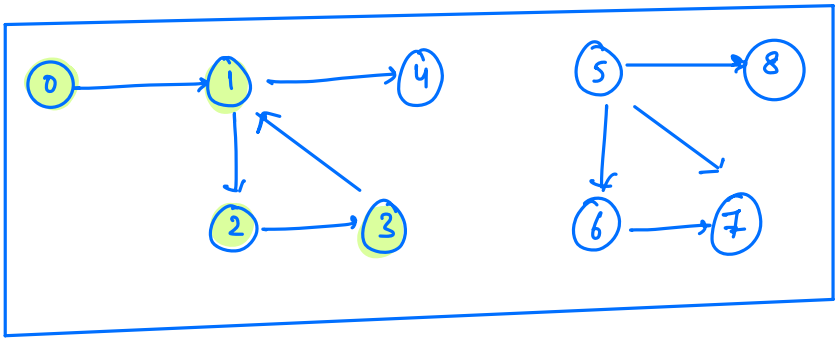
code →

```
boolean visited [N], // ∀i, visited [i] = false;
boolean path [N] , // ∀i, path [i] = false;

for( i = 0; i < N; i++){
    if( visited [i] == false){
        if ( dfs ( graph, i, visited, path) == true){
            return true;
        }
    }
}
return false;
```

```
boolean dfs ( Graph , src , visited[N], path[N] ){
    visited[src] = true;
    path[src] = true;
    for( int nbr : graph[src]){
        if( path[nbr] == true){ //if nbr is already present
                                //in current path
            return true;
        }
        if( visited[nbr] == false && dfs(graph, nbr, visited, path)){
            return true;
        }
    }
    path[src] = false; //removing src from curr path before
                       //returning from src.
    return false;
}
```

T.C → O(N+E)
S.C → O(N)

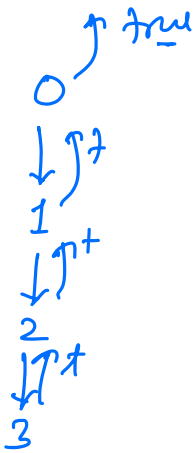


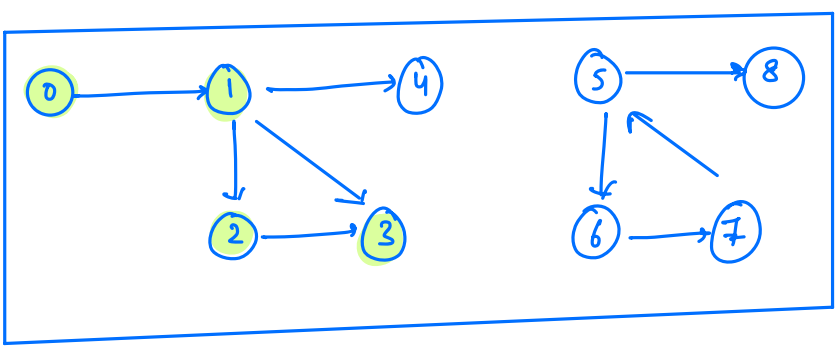
visited [ ] →

0	1	2	3	4	5	6	7	8	9
t	t	t	t	f	f	f	f	f	f

path [ ] →

t	t	t	t	f	f	f	f	f	f





60-70% → BFS, DFS