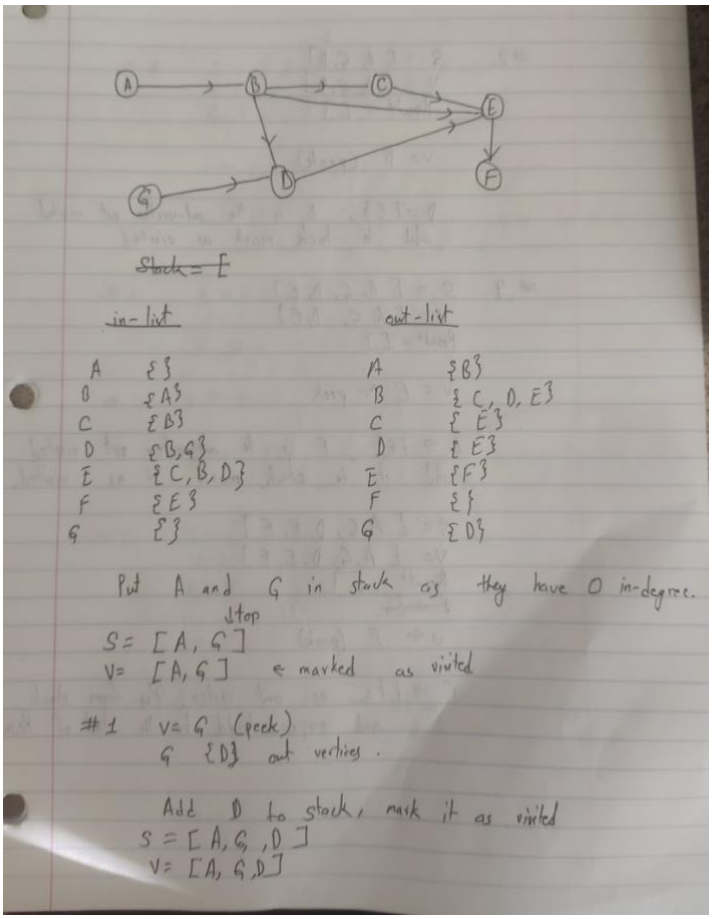
Answer of 1



~~Stack = E~~

in-list

A	{}
B	{A}
C	{B}
D	{B, G}
E	{C, B, D}
F	{E}
G	{}

out-list

A	{B}
B	{C, D, E}
C	{E}
D	{E}
E	{F}
F	{}
G	{D}

Put A and G in stack as they have 0 in-degree.

top

S = [A, G]

V = [A, G] ← marked as visited

#1 v = G (peek)

G {D} out vertices.

Add D to stack, mark it as visited

S = [A, G, D]

V = [A, G, D]

#2 S = [A, G, D] ↓
V = [A, G, D]
Result = []

v = D (peek)

D → {E}, E is the out-vertex not visited
add to stack, mark as visited.

#3 S = [A, G, D, E]
V = [A, G, D, E]
Result = []

v = E ← peek

E → {F}, F is the out-vertex not visited
add it to stack, mark it as visited.

S = [A, G, D, E, F]
V = [A, G, D, E, F]
Result = []
~~F → {}~~

v ← F (peek)

F → {}, no out vertex. Pop from stack
and prepend/add to the start of Result.

#4 S = [A, G, D, E]
V = [A, G, D, E, F]
Result = [F]

v ← E peek

E → {F}, all out-vertices visited. Pop from stack and add to the first of list.

#5 S = [A, G, D]
V = [A, G, D, E, F]
Result = [E, F]

v ← D

D → {E}, all out vertices visited, Pop from stack and add to the first of Result.

#6. S = [A, G]
V = [A, G, D, E, F]
Result = [D, E, F]

v ← G

G → {D}, all out-vertices visited. Pop from stack and add it to the first of result.

#7 S = [A]
V = [A, G, D, E, F]
Result = [G, D, E, F]

v ← A (peek)

A → {B}, B not visited. push to stack and mark as visited.

#8. S = [A, B]
V = [A, G, D, E, F, B]
Result = [G, D, E, F]

v ← B

B → {C, D, E}, C is not visited. Add to stack and mark as visited.

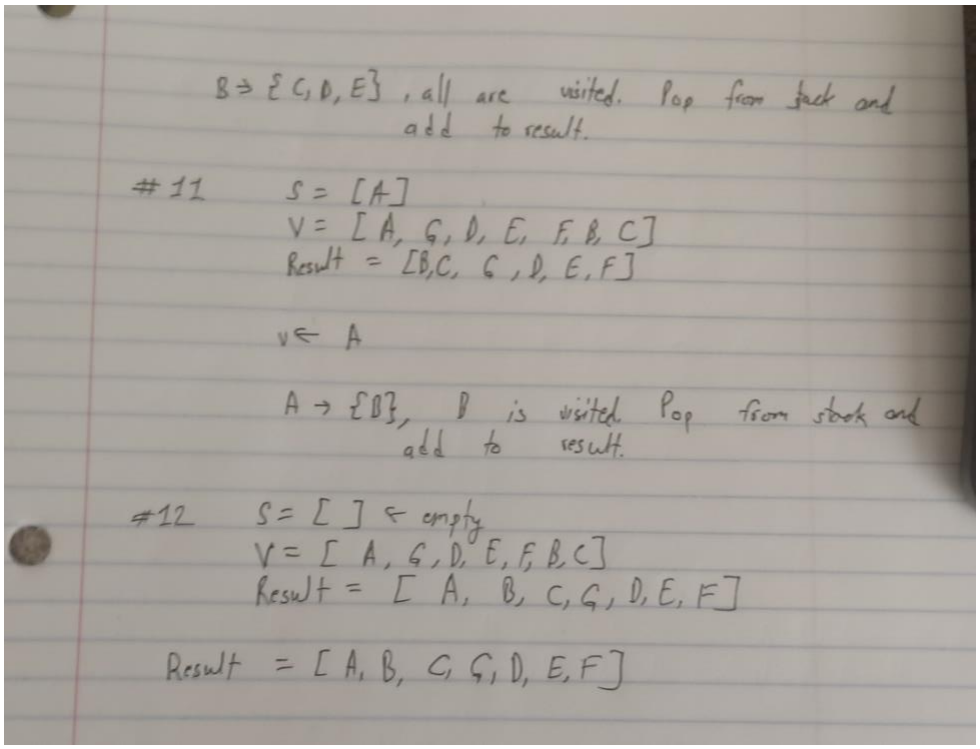
#9 S = [A, B, C]
V = [A, G, D, E, F, B, C]
Result = [G, D, E, F]

v ← C (peek).

C → {E}, E is already visited. Pop and add it to start of result.

#10 S = [A, B]
V = [A, G, D, E, F, B, C]
Result = [C, G, D, E, F]

v ← B (peek)



Answer of 2

Algorithm: IsReachableFrom(G, u, v)
Input: A directed graph G, vertices u, v in G
Output: TRUE if there is a directed path from u to v in G, false otherwise.

Initialize a stack S //supports backtracking
Mark s as visited

S.push(s)

while S ≠ ∅ do
    v' ← S.peek()

    if some out vertex of v' not yet visited then
        w ← next out vertex of v (i.e. (v',w) in E)

        if w = v then
            return TRUE
        mark w
        push w onto S
    else //if can't find such a w,

backtrack S.pop()

return FALSE

Answer of 3

```
import java.util.*;

class Solution {
    public int[] findOrder(int numCourses, int[][] prerequisites) {
        // Edge case: no prerequisites, return a range in order
        if (prerequisites.length == 0) {
            int[] order = new int[numCourses];
            for (int i = 0; i < numCourses; i++) {
                order[i] = i;
            }
            return order;
        }

        // Create adjacency lists for in-degrees and out-degrees
        Map<Integer, List<Integer>> inList = new HashMap<>();
        Map<Integer, List<Integer>> outList = new HashMap<>();
        Set<Integer> vertices = new HashSet<>();

        // Initialize the maps
        for (int i = 0; i < numCourses; i++) {
            inList.put(i, new ArrayList<>());
            outList.put(i, new ArrayList<>());
            vertices.add(i);
        }

        // Build the graph
        for (int[] prerequisite : prerequisites) {
            int inVertex = prerequisite[1];
            int outVertex = prerequisite[0];
            outList.get(inVertex).add(outVertex);
            inList.get(outVertex).add(inVertex);
        }

        // Find vertices with zero in-degrees to start the process
        List<Integer> zeroInDegree = new ArrayList<>();
        for (int v : vertices) {
            if (inList.get(v).isEmpty()) {
                zeroInDegree.add(v);
            }
        }

        List<Integer> result = new ArrayList<>();  // List to store the
topological order
        Set<Integer> visited = new HashSet<>();
        Set<Integer> path = new HashSet<>();  // Set to detect cycles during
DFS

        // Perform DFS from all vertices with zero in-degrees
        for (int vertex : zeroInDegree) {
```

```
            if (!dfs(vertex, outList, visited, path, result)) {
                return new int[0]; // If a cycle is detected, return an empty
array
            }
        }

        // If not all courses are visited, return an empty list (unreachable
nodes)
        if (visited.size() != numCourses) {
            return new int[0];
        }

        // Reverse the result to get the correct topological order
        Collections.reverse(result);

        // Convert the result list to an array
        return result.stream().mapToInt(i -> i).toArray();
    }

    // Helper function for DFS
    public static boolean dfs(int vertex, Map<Integer, List<Integer>>
outList, Set<Integer> visited, Set<Integer> path, List<Integer> result) {
        if (path.contains(vertex)) {
            return false; // Cycle detected
        }
        if (visited.contains(vertex)) {
            return true; // Vertex already processed
        }

        path.add(vertex);
        visited.add(vertex);

        for (int v : outList.get(vertex)) {
            if (!dfs(v, outList, visited, path, result)) {
                return false; // Cycle detected in path starting at v
            }
        }

        path.remove(vertex);
        result.add(vertex);
        return true;
    }
}
```

Answer of 4

```
import java.util.*;

class Solution {
    public boolean canFinish(int numCourses, int[][] prerequisites) {
        // Edge case: no prerequisites, return true (all courses can be
finished)
        if (prerequisites.length == 0) {
```

```
            return true;
        }

        // Create adjacency lists for in-degrees and out-degrees
        Map<Integer, List<Integer>> inList = new HashMap<>();
        Map<Integer, List<Integer>> outList = new HashMap<>();
        Set<Integer> vertices = new HashSet<>();

        // Initialize the maps
        for (int i = 0; i < numCourses; i++) {
            inList.put(i, new ArrayList<>());
            outList.put(i, new ArrayList<>());
            vertices.add(i);
        }

        // Build the graph
        for (int[] prerequisite : prerequisites) {
            int inVertex = prerequisite[1];
            int outVertex = prerequisite[0];
            outList.get(inVertex).add(outVertex);
            inList.get(outVertex).add(inVertex);
        }

        // Find vertices with zero in-degrees to start the process
        List<Integer> zeroInDegree = new ArrayList<>();
        for (int v : vertices) {
            if (inList.get(v).isEmpty()) {
                zeroInDegree.add(v);
            }
        }

        Set<Integer> visited = new HashSet<>();
        Set<Integer> path = new HashSet<>();  // Set to detect cycles during
DFS

        // Perform DFS from all vertices with zero in-degrees
        for (int vertex : zeroInDegree) {
            if (!dfs(vertex, outList, visited, path)) {
                return false;  // If a cycle is detected, return false
            }
        }

        // If not all courses are visited, return false (some nodes are
unreachable)
        return visited.size() == numCourses;
    }

    // Helper method for DFS
    private boolean dfs(int vertex, Map<Integer, List<Integer>> outList,
Set<Integer> visited, Set<Integer> path) {
        if (path.contains(vertex)) {
            return false; // Cycle detected
        }
        if (visited.contains(vertex)) {
            return true; // Vertex already processed
        }
```

```
        path.add(vertex);
        visited.add(vertex);

        for (int v : outList.get(vertex)) {
            if (!dfs(v, outList, visited, path)) {
                return false; // Cycle detected in path starting at v
            }
        }

        path.remove(vertex);
        return true;
    }
}
```