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Group F

Topic 4

Directed graph, fundamental of computer recognition, zero-one matrix, in-degree, out-degree.

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Vertex

A vertex is a point where multiple lines meet. It is also called a **node.** Similar to points, a vertex is also denoted by an alphabet..

Example

Edge

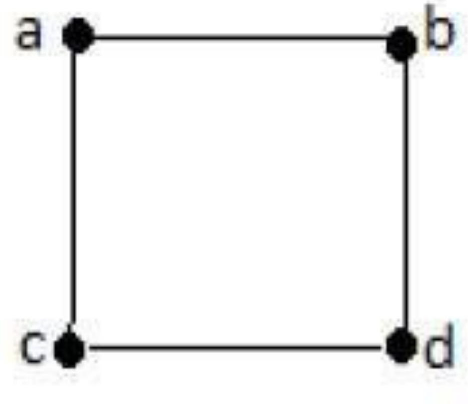
An edge is a mathematical term for a line that connects two vertices. Many edges can be formed from a single vertex. Without a vertex, an edge cannot be formed. There must be a starting vertex and an ending vertex for an edge.

Example

Graph

A graph ‘G’ is defined as G = (V, E) Where V is a set of all vertices and E is a set of all edges in the graph.

Example



Loop

In a graph, if an edge is drawn from the vertex to itself, it is called a loop.

Example

Directed Graph

- A directed graph is graph is a set of vertices or nodes that are connected together by edges and are directed from one vertex to another.

- A directed graph, also called a digraph, is a graph in which the edges have a direction.

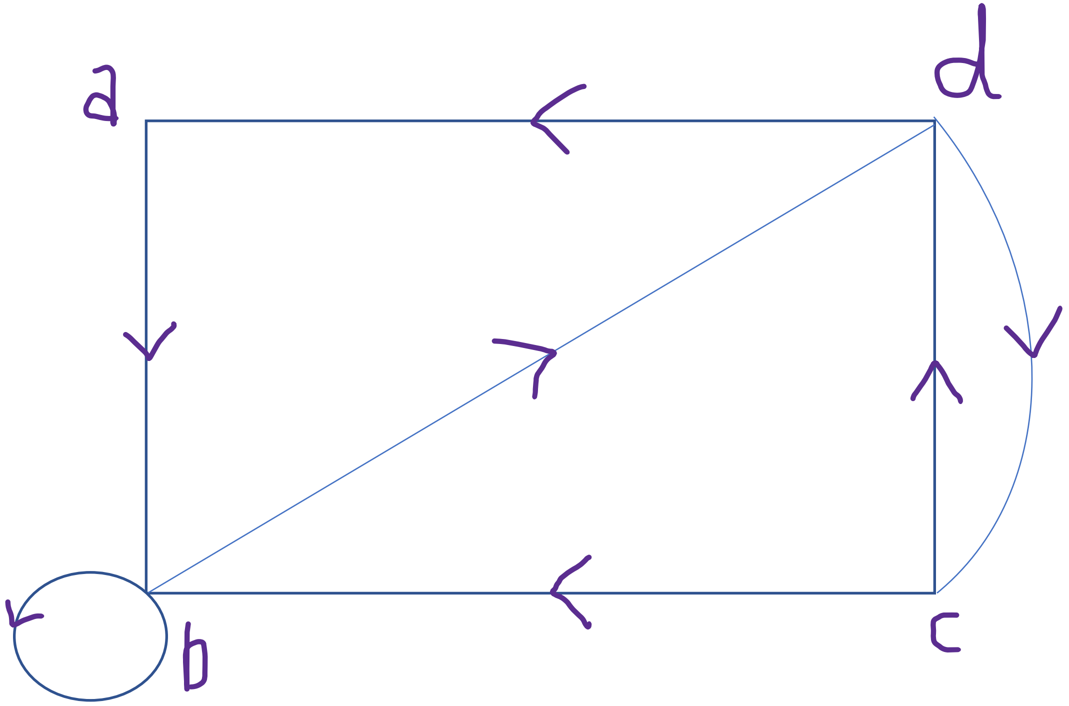
- This is usually indicated with an arrow on the edge.

Example

Consider A={a,b,c,d}

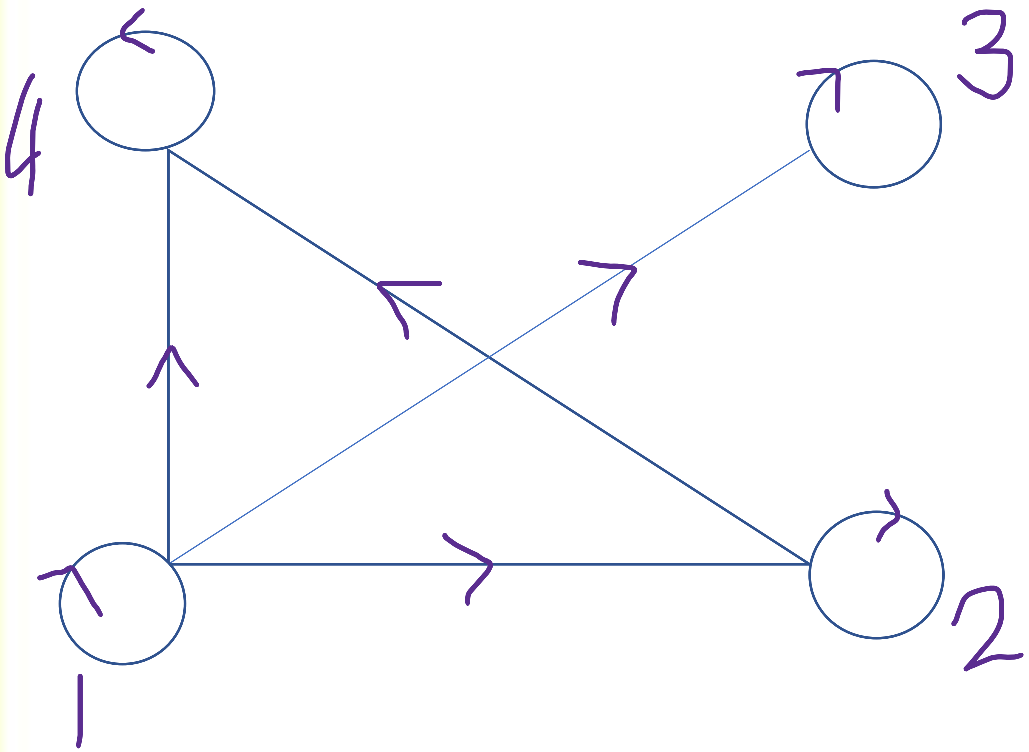
R={(a,b),(b,b),(b,d),(c,b),(c,d),(d,a),(d,c)}

Draw the diagraph.



Example

Write relation for given diagraph.



A) R={(1,1),(1,2),(1,3),(1,4),(2,2),(2,4),(3,3),(4,4)}

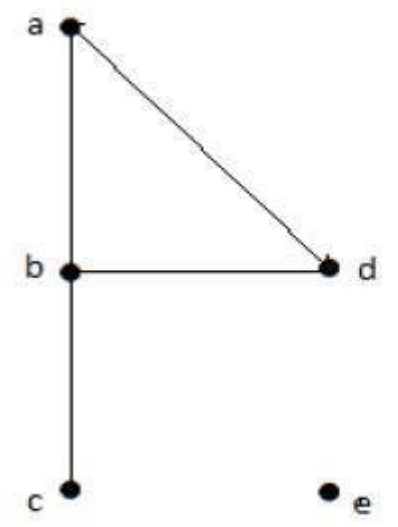
Degree of Vertex

It is the number of vertices adjacent to a vertex V.

Notation − deg(V).

In a simple graph with n number of vertices, the degree of any vertices is **deg(v) ≤ n – 1 ∀ v ∈ G.**

Degree of Vertex in an Undirected Graph



In the above Undirected Graph,

- deg(a) = 2, as there are 2 edges meeting at vertex 'a'.
- deg(b) = 3, as there are 3 edges meeting at vertex 'b'.
- deg(c) = 1, as there is 1 edge formed at vertex 'c'

So 'c' is a **pendent vertex**.

- deg(d) = 2, as there are 2 edges meeting at vertex 'd'.
- deg(e) = 0, as there are 0 edges formed at vertex 'e'.

So 'e' is an **isolated vertex**.

Degree Of Vertex In a Directed Graph

In a directed graph, each vertex has an **indegree** and an **outdegree**.

Indegree of a Graph

The indegree of vertex V is the number of edges that are coming into the vertex V.

Notation − $\deg^{-}(V)$.

Outdegree of a Graph

Outdegree of vertex V is the number of edges that are going out from the vertex V.

Notation − $\deg^{+}(V)$.

Example

Take a look at the following directed graph. Vertex 'a' has two edges, 'ad' and 'ab', which are going outwards. Hence its outdegree is 2. Similarly, there is an edge 'ga', coming towards vertex 'a'. Hence the indegree of 'a' is 1.

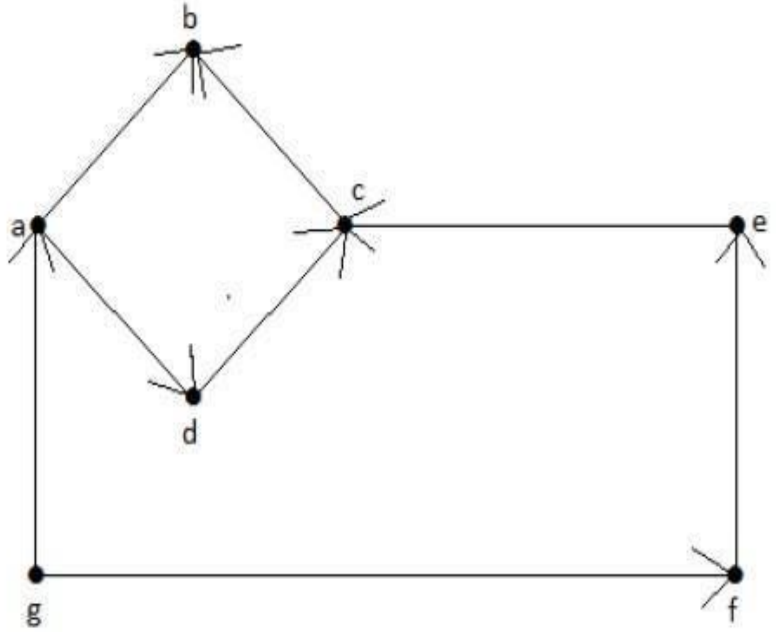


Table for given Example

The indegree and outdegree of other vertices are shown in the following table −

Vertex	Indegree	Outdegree
a	1	2
b	2	0
c	2	1
d	1	1
e	1	1
f	1	1
g	0	2

Pendent Vertex

By using a degree of a vertex, we have two special types of vertices. A vertex with degree one is called a pendent vertex

Example

Isolated Vertex

A vertex with degree zero is called an isolated vertex.

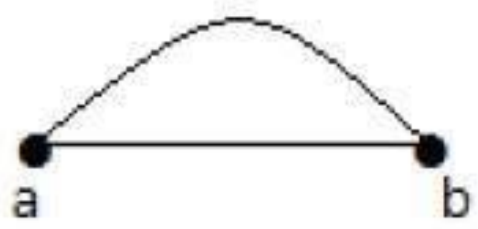
Example

- d

Parallel Edges

In a graph, if a pair of vertices is connected by more than one edge, then those edges are called parallel edges.

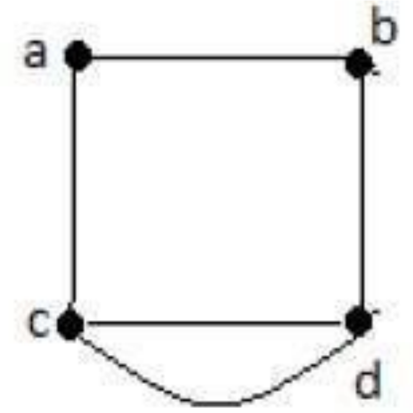
Example



Multi Graph

A graph having parallel edges is known as a Multigraph.

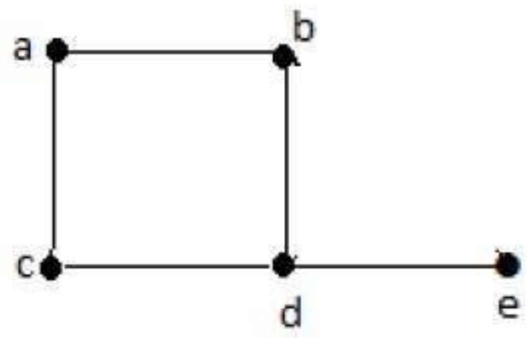
Example



Degree Sequence of a Graph

If the degrees of all vertices in a graph are arranged in descending or ascending order, then the sequence obtained is known as the degree sequence of the graph.

Example



Vertex	A	b	c	d	e
Connecting to	b,c	a,d	a,d	c,b,e	d
Degree	2	2	2	3	1

Zero –One Matrix

- A matrix where all entries are either 0 or 1 is called **Zero – One Matrix.**
- Zero – One matrix are based on Boolean Operations.

$$b1 \wedge b2 = \begin{cases} 1 & \text{if } b1=b2=1 \\ 0 & \text{otherwise} \end{cases} \qquad \text{“meet”}$$

$$b1 \vee b2 = \begin{cases} 1 & \text{if } b1=1 \text{ or } b2=1 \\ 0 & \text{otherwise} \end{cases} \qquad \text{“join”}$$

Table for given Example

The indegree and outdegree of other vertices are shown in the following table −

Vertex	Indegree	Outdegree
a	1	2
b	2	0
c	2	1
d	1	1
e	1	1
f	1	1
g	0	2

d

Example 1

1. Find the join and meet of A and B

$$A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Example 2

2. R1 = { (1, 1) (1, 3) (2, 2) }

R2 = { (1, 1) (1, 2) (2, 1) (2, 2) } Find the join and meet of A and B, also find DIGRAPH

$$A = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 0 \end{bmatrix}$$

Adjacent List

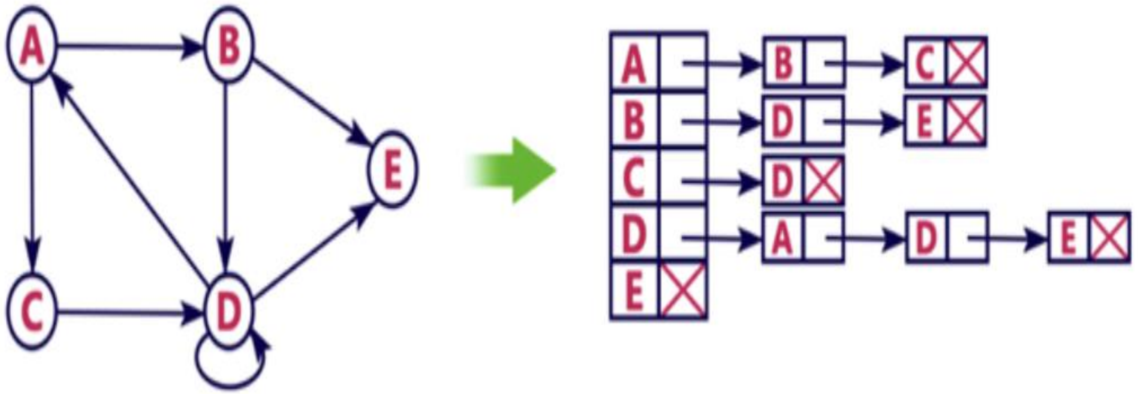
- Adjacency list is a linked representation.

- In this representation for each every vertex of the graph contains list of adjacent vertices.

- An array of vertices which is indexed by the vertex number for each vertex V,the corresponding array element points to a SINGLE LINKED LIST of neighbour of V.

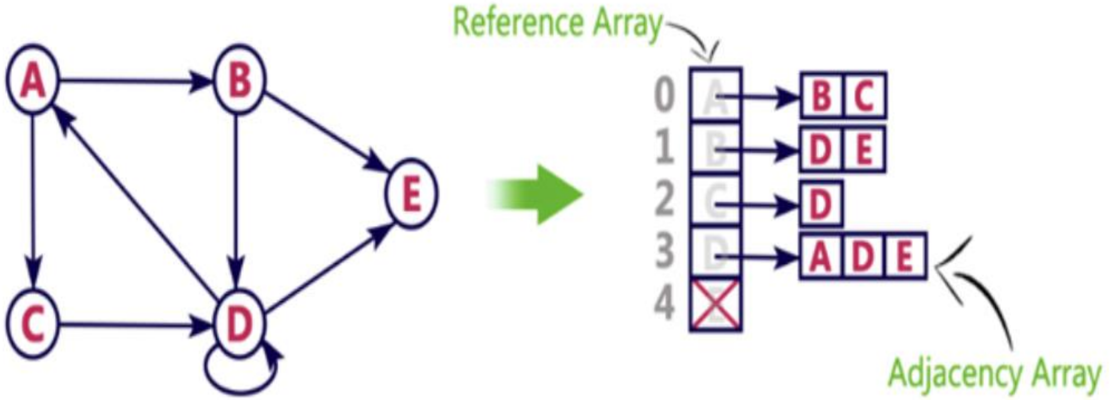
Adjacent List

Example : let see the following directed graph representation implemented using linked list :



Adjacent List

We can also implement this representation using array as follows :



Adjacent List

Pros :

- Adjecency list saves lot of space.
- We can easily insert or delete as we use linked list.
- Representation is easy to follow and clearly shows the adjacent nodes of node.

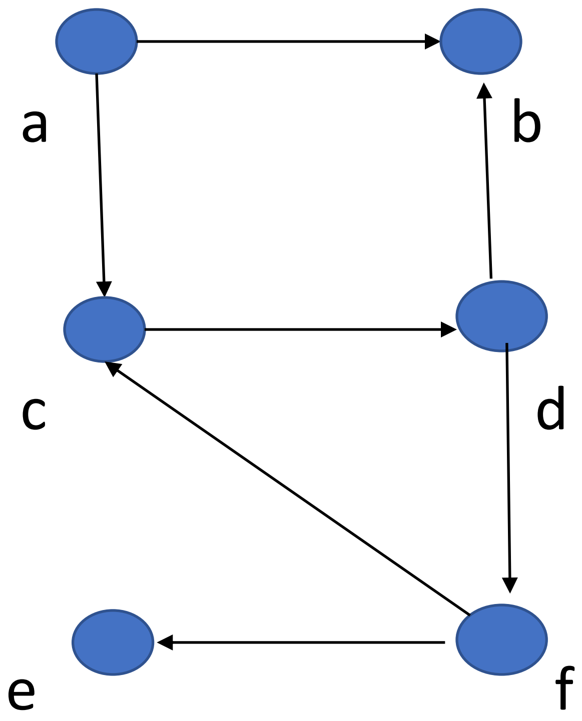
Adjacent List

cons :

- The adjacency list allows testing we there two vertices are adjacent to each other but it is slower to support this operation.

Adjacent List

Some important sums on adjacency list :

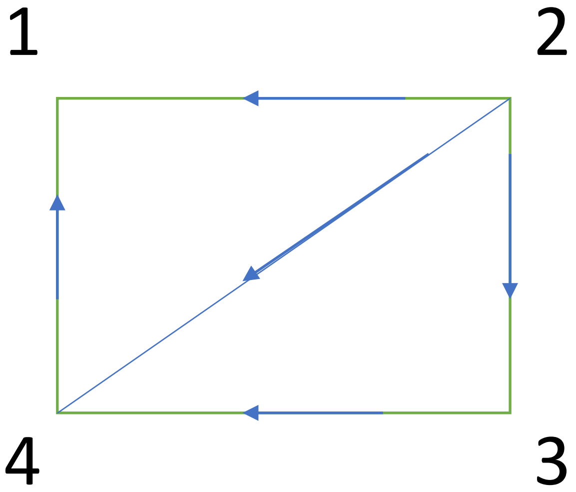


Indegree

DEFINITION :

- The number of edges directed **into** a vertex in a directed graph is called **Indegree**.
- It is denoted by : deg-(vertex)

Example



d-(v)=?

d-(1)=2

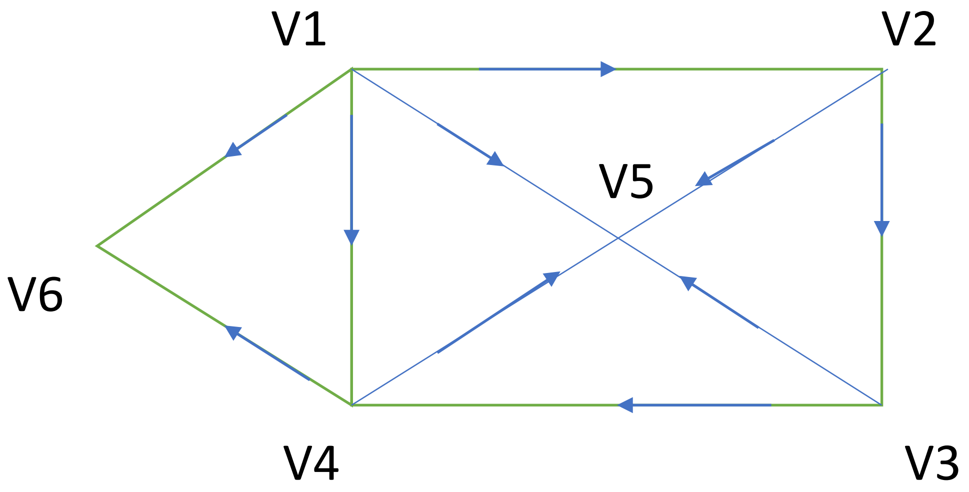
d-(2)=0

d-(3)=1

d-(4)=2

Problem

1. a) Calculate the Indegree of the vertices in the following graph:

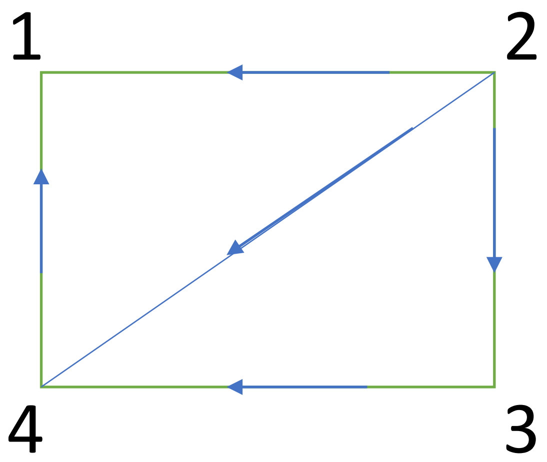


Outdegree

DEFINITION :

- The number of edges directed **out** of a vertex in a directed graph is called **Outdegree**.
- It is denoted by : deg+(Vertex)

Example



d+(v)=

d+(1)=0

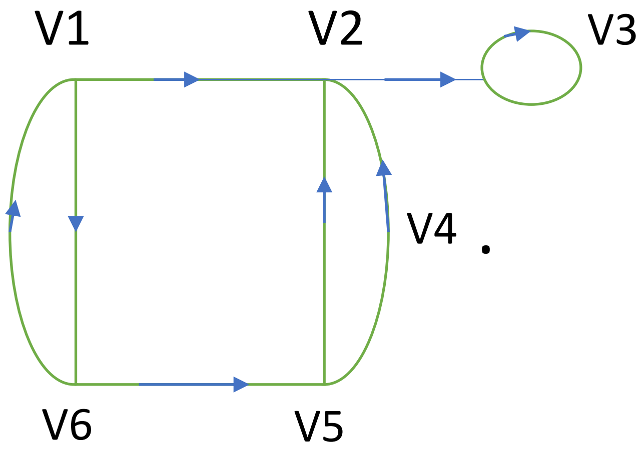
d+(2)=3

d+(3)=1

d+(4)=1

Problem

a) Calculate the Outdegree of the vertices in the following graph:



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Thank You.