Graph

- *Non-Linear Data Structure*
- *Collection of vertices that have data and are connected to other vertices*

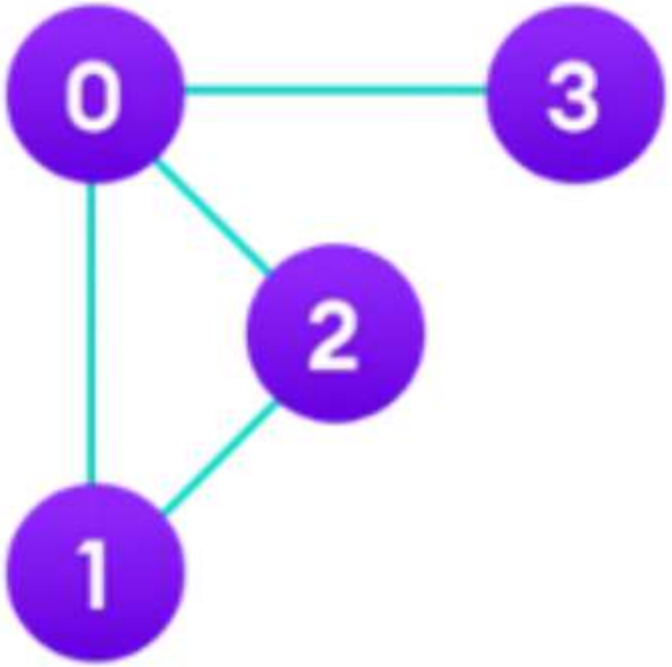
- ***Example 1 – Social Media***
  - *Users on social networking sites such* ***as Facebook, WhatsApp, Messenger, Twitter, Google+, LinkedIn, etc.*** *are linked through a large graph*
  - *Here, people or users are represented by the* ***vertices*** *and any connection between the users, such as followers, friendships, likes, or subscriptions, is represented by the* ***edges***

- ***Example 2 – Graphs used in connecting people through viral videos***
  - *Each user is a* ***vertex*** *in this case, and when users connect, they form an* ***edge****. When a video reaches a certain number of connections/views, it is said to be viral.*

- ***Example 3 – Google Maps***
  - *In Google Maps, various locations are represented as* ***vertices*** *and the roads are represented as* ***edges.***
  - *Graph theory is used to* ***find the shortest path in road or a network***

Few more examples for Graph

- *Web Page Searching,*
- *City Planning,*
- *Traffic Control,*
- *Transportation & Navigation,*
- *Travelling Salesman Problem,*
- *GSM mobile phone networks, etc.*
- ***Graph Theory***
  - *Graph theory can also be used to determine how viruses spread across borders or cities.*
  - *Graph theory is used in biology and medicine to distinguish drug targets, decide the job of proteins, or determine the qualities of vague capacity.*



In the graph,

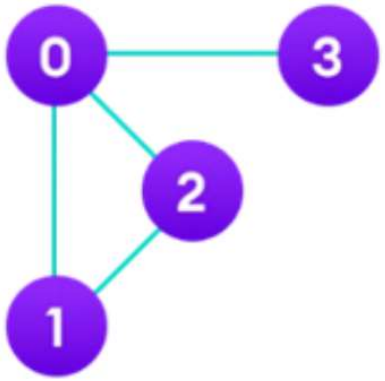
V = {0, 1, 2, 3}

E = {(0,1), (0,2), (0,3), (1,2)}

G = {V, E}

Graph Terminologies

- ***Vertex*** *- It's a fundamental unit from which the graph is formed. It contains data. It is also known as nodes. A vertex is usually represented by a circle with a label.*
    - *In the above graph, 0, 1, 2 and 3 are the vertices*
- ***Edge*** *- It's a link connecting the two vertices. An edge is represented by a line or arrow extending from one vertex to another.*
    - *In the above, there is edge between vertex 0 and vertex 1*
- ***Adjacency*** *- A vertex is said to be adjacent to another vertex if there is an edge connecting them.*
    - *In the above graph, Vertices 2 and 1 are adjacent because there is an edge between them.*
- ***Path*** *- A sequence of edges that allows you to go from vertex A to vertex B is called a path.*
    - *In the above graph, paths from vertex 0 to vertex 2 are 0 - 1, 1 - 2 and 0 - 2*
- ***Cycle*** *- A path that starts from a given vertex and ends at the same vertex is called a cycle*
    - *In the above graph, there is cycle: 0 – 1 – 2 – 0*
- ***Degree*** *- The degree of a vertex of a graph is the number of edges that are incident to the vertex. It is usually represented as Degree (Vertex)*
    - *The degree of all the vertices in the above graph is*
        - *Degree (0) = 3*
        - *Degree (1) = 2*
        - *Degree (2) = 2*
        - *Degree (3) = 1*

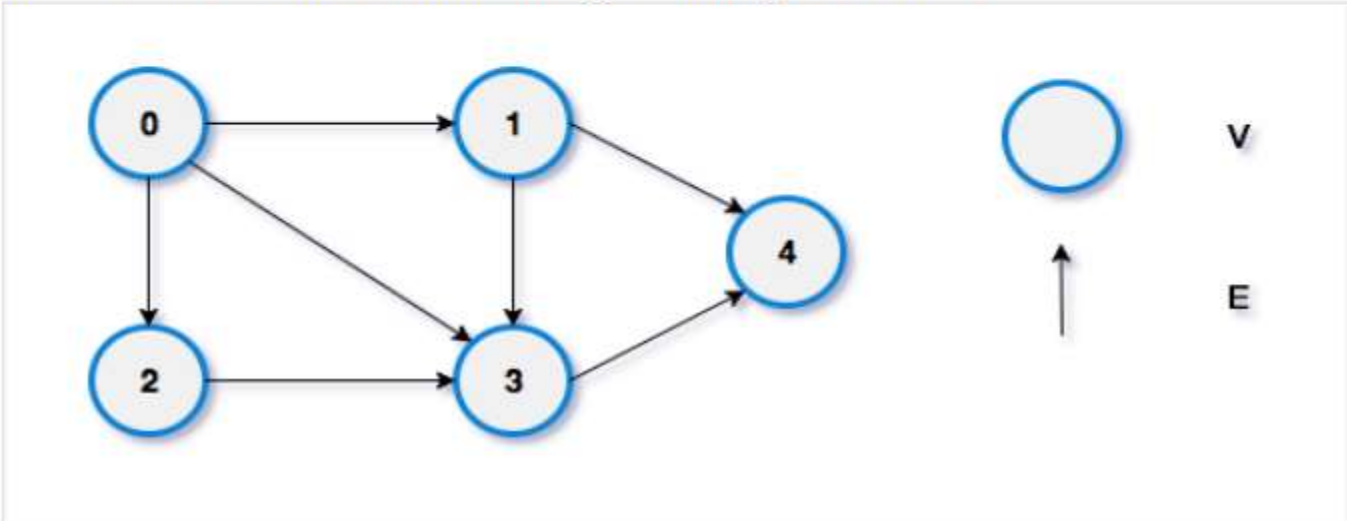


Types of Graph

- *Directed Graph*
- *Undirected Graph*
- *Connected Graph*
- *Disconnected Graph*
- *Complete Graph*
- *Weighted Graph*
- *Cyclic Graph*
- *Acyclic Graph*

Directed Graph

- A directed graph is a graph in which the edges are directed by arrows.
- Directed graphs are also known as digraphs.
- In the directed graph, we have in-degree and out-degree for every vertex.
- In-degree of a vertex is the number of edges coming to the vertex.

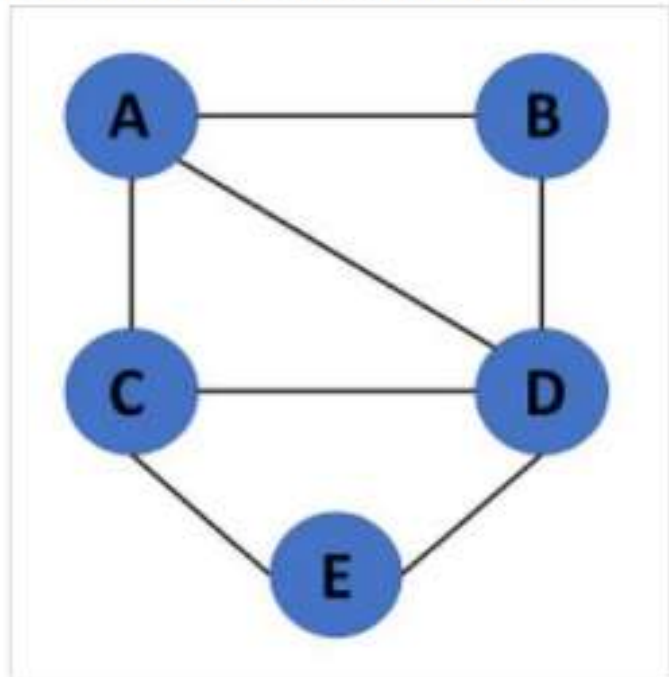


1) In-degree (0) = 0
2) In-degree (1) = 1
3) In-degree (2) = 1
4) In-degree (3) = 3
5) In-degree (4) = 2

- Out-degree of a vertex is the number edges which are coming out from the vertex.
  1) Out-degree (0) = 3
  2) Out-degree (1) = 2
  3) Out-degree (2) = 1
  4) Out-degree (3) = 1
  5) Out-degree (4) = 0

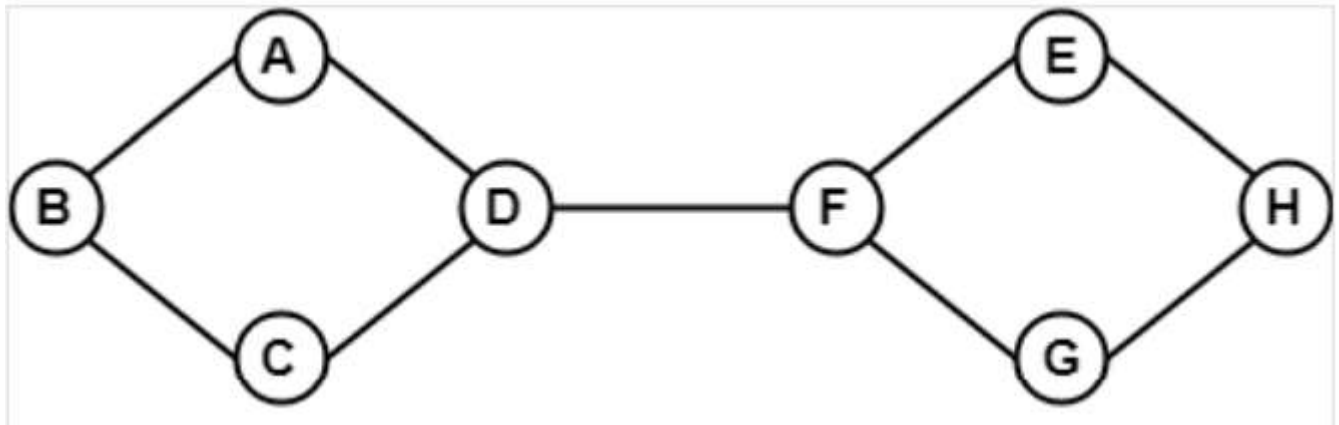
Undirected Graph

- An undirected graph is a graph whose edges are not directed.



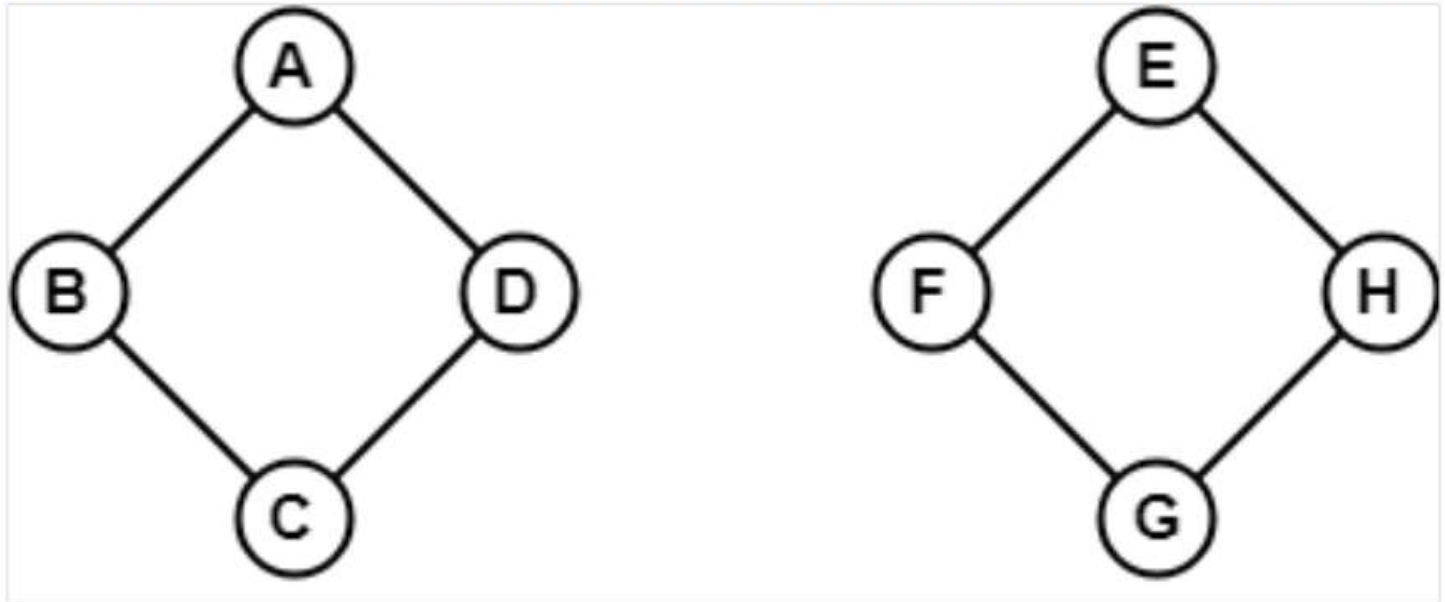
Connected Graph

- A connected graph is a graph in which at least one edge or path exists between every pair of vertices.



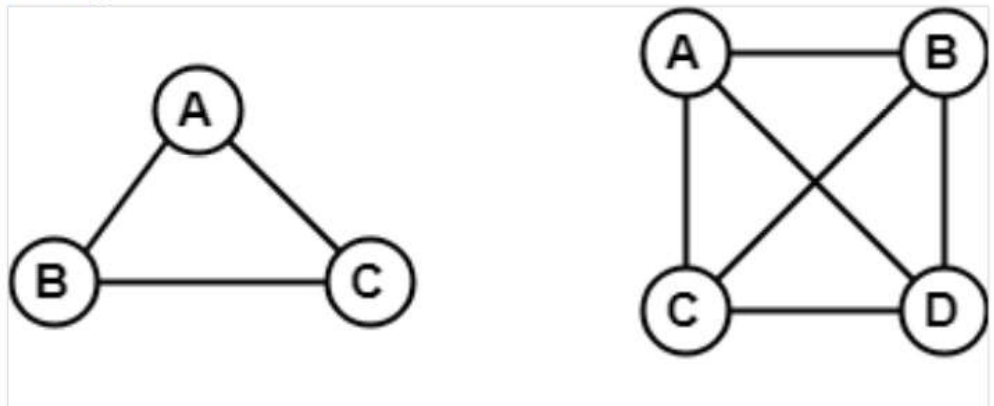
Disconnected Graph

- A disconnected graph is a graph in which any path does not exist between every pair of vertices.



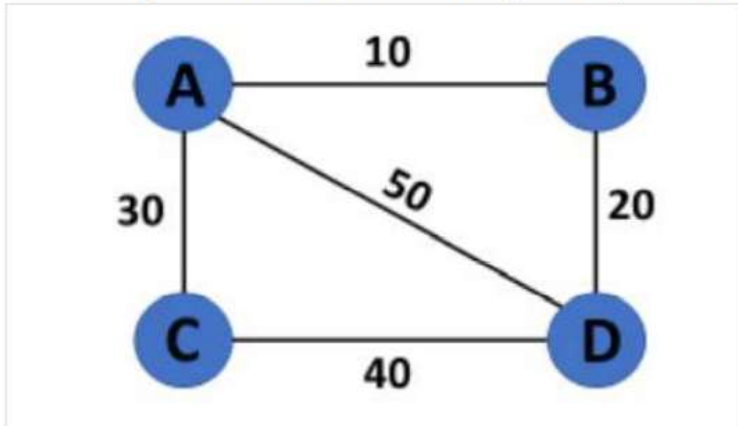
Complete Graph

- A complete graph is a graph in which every pair of vertices is connected by exactly one edge. So, a complete graph on n vertices contains n(n - 1)/2 edges



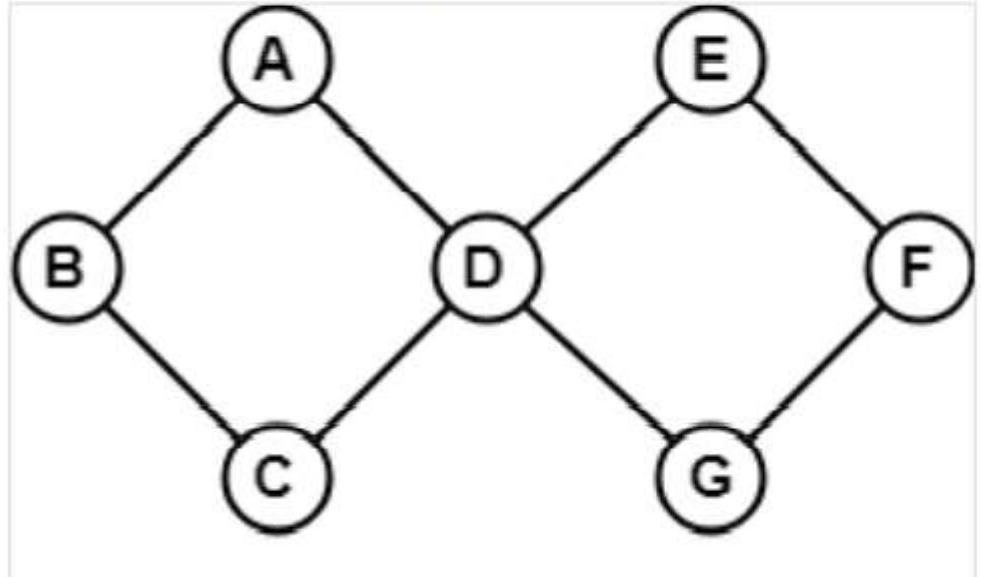
Weighted Graph

- A graph weighted graph in which each edge has a value or weight representing the cost of traversing that edge.



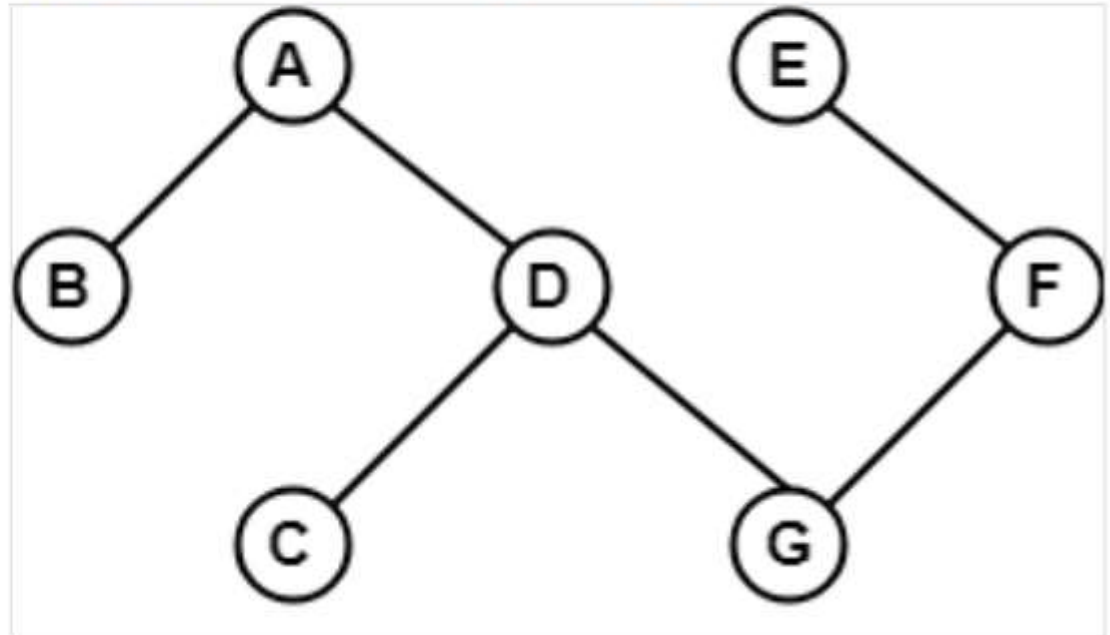
Cyclic Graph

- A graph which contains any cycle in it is called as a cyclic graph.



Acyclic Graph

- A graph which does not contain any cycle in it is called an acyclic graph.



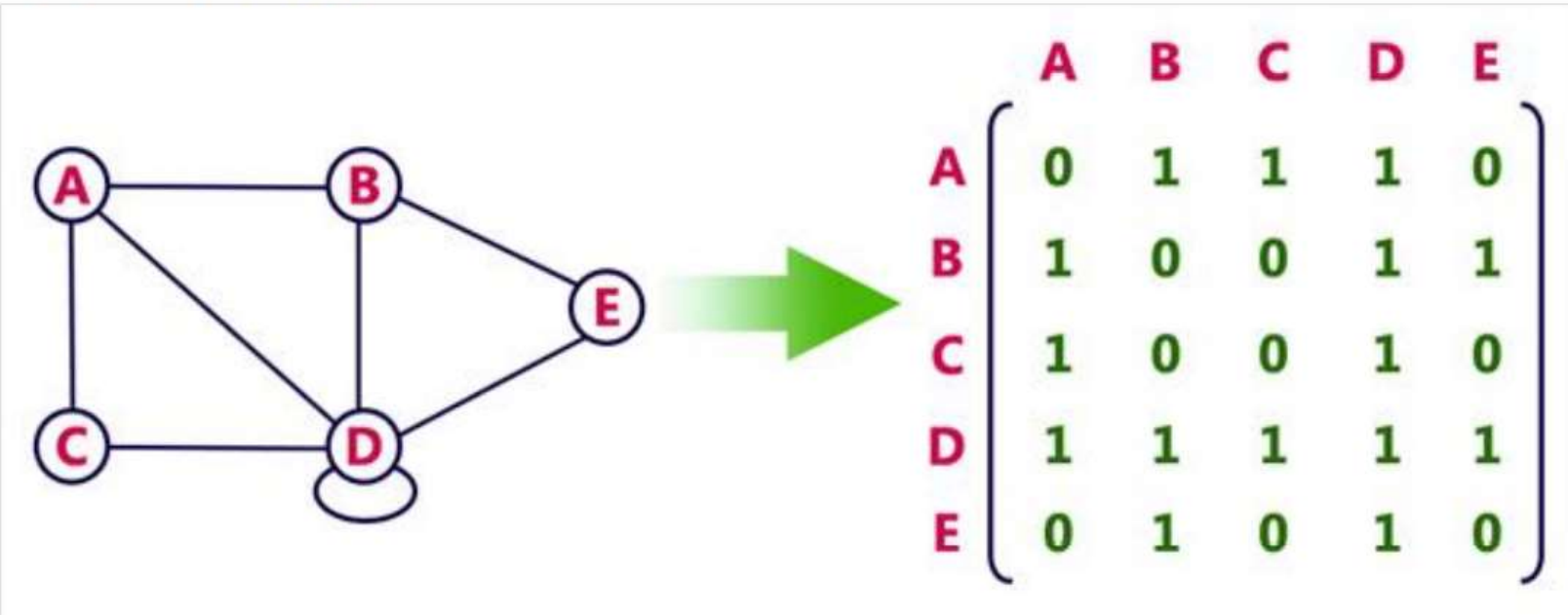
Graph Representation

Graphs are commonly represented in two ways:

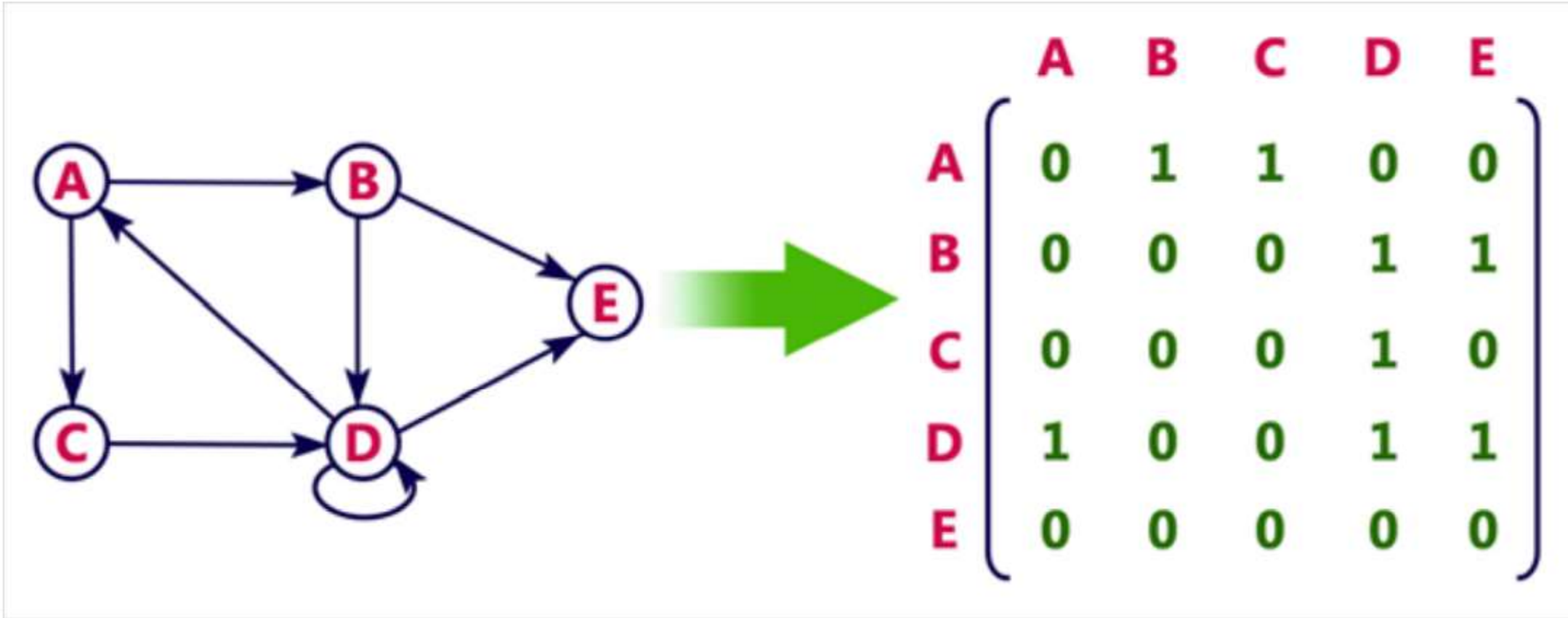
- *Adjacency Matrix*
- *Adjacency Lists*

Adjacency Matrix

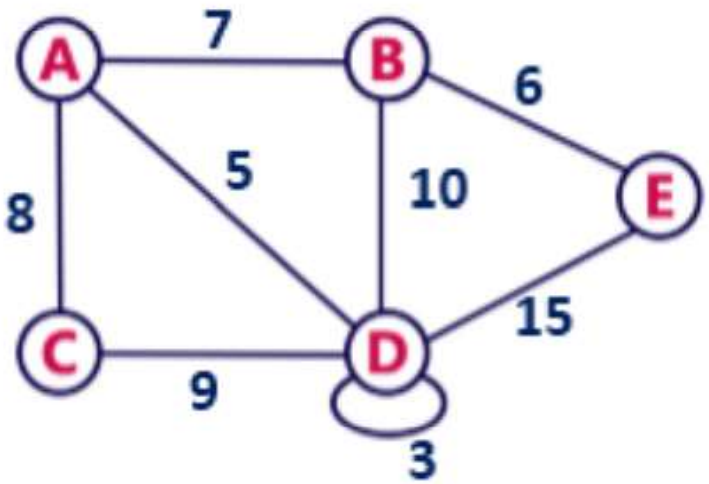
- An adjacency matrix is a 2D array of V x V vertices.
- Each row and column represent a vertex.
- If the value of any element a[i][j] is 1, it represents that there is an edge connecting vertex i and vertex j.
- For undirected graph



For directed graph,



For undirected weighted graph



	A	B	C	D	E
A	0	7	8	5	0
B	7	0	0	10	6
C	8	0	0	9	0
D	5	10	9	3	15
E	0	6	0	15	0

Adjacency Lists

- An adjacency list represents a graph as an array of linked lists.
- The index of the array represents a vertex and each element in its linked list represents the other vertices that form an edge with the vertex.