CIRCUIT THEORY

SAIBAL DUTTA

LECTURE-1

GRAPH THEORY

- Why graph theory in circuit theory?
- Mathematical Topic
- Network with 100 loops → 100 KVL/Maxwell loop equations needed to determine unknown currents
- Network with 101 nodes → 100 KCL/node equations to determine unknown node potentials
- Impossible to solve 100 simultaneous equation manually
- Need a digital computer to solve 100 simultaneous equation

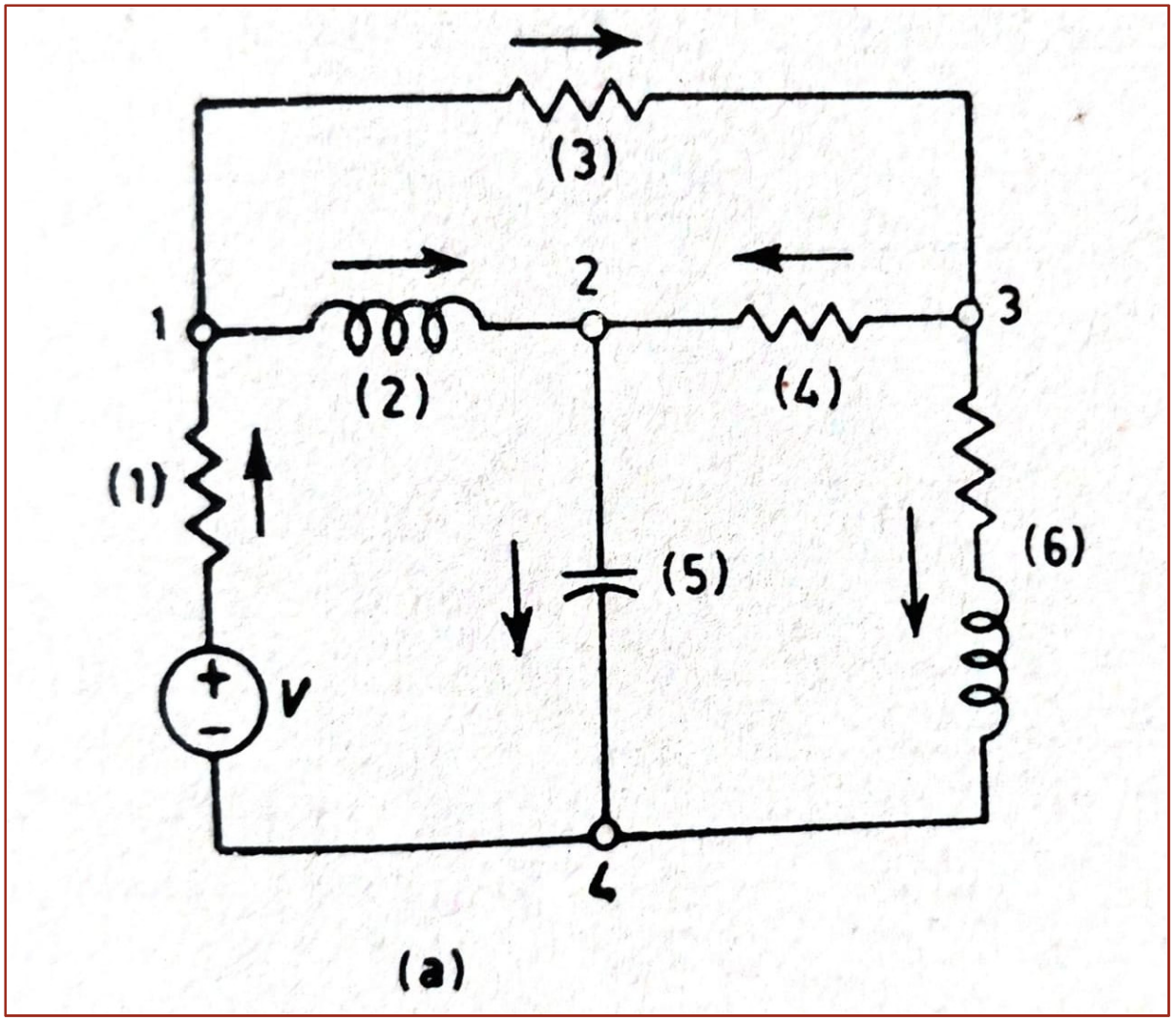
Graph Theory is used to analyse large/complicated electrical network

What is Graph?

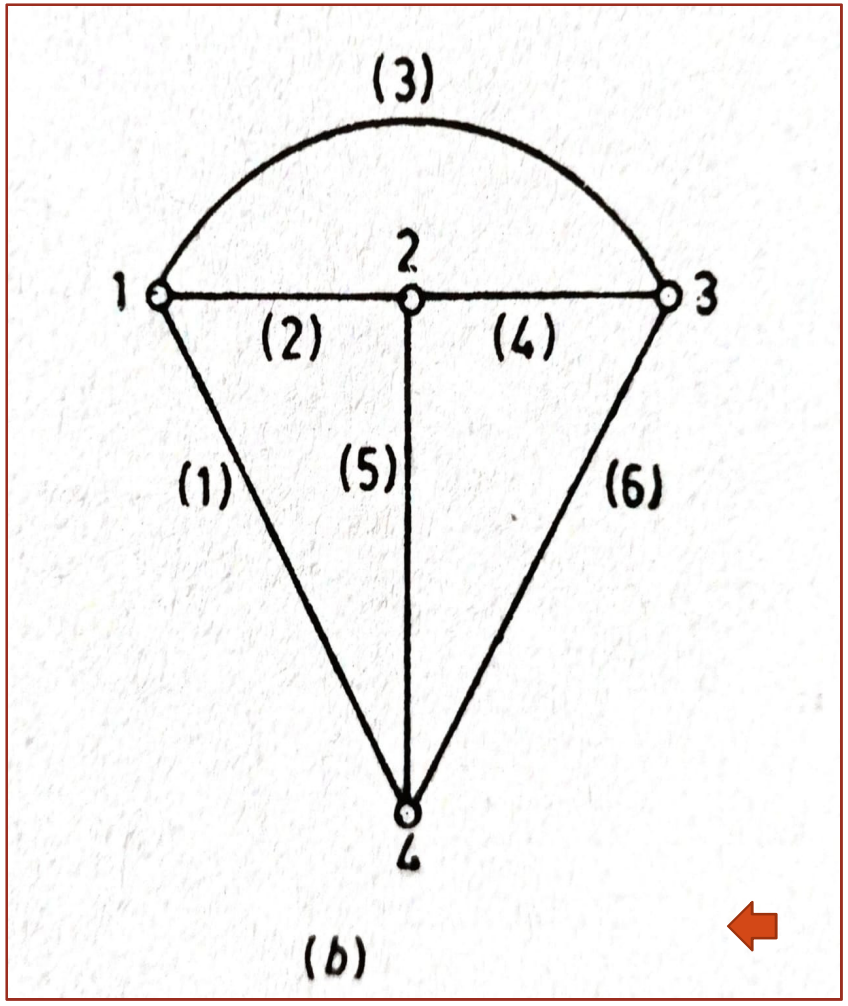
- A graph is a collection of points called nodes and line segments called branches, where nodes are being by the braches.

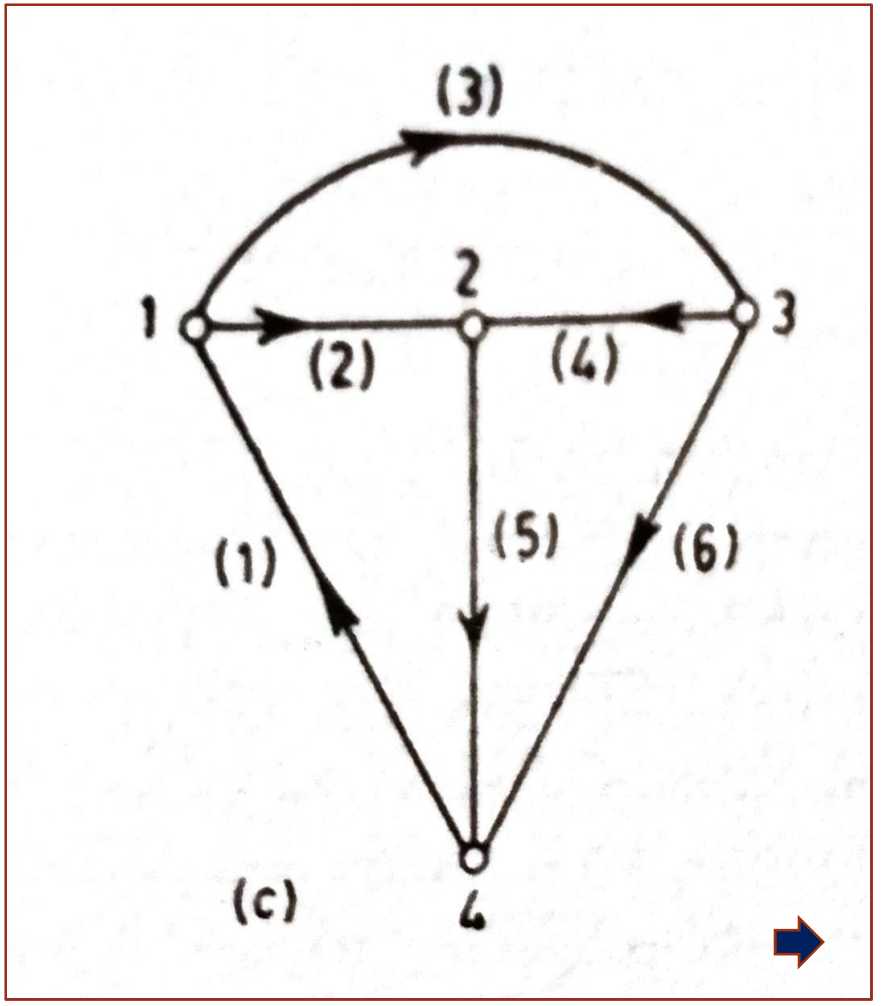
How to draw the Graph of an Electrical Network?

- Replace all network elements (R/L/C) by line segments
- Replace energy source by their internal impedance
- The internal impedance of an ideal voltage source is zero → replaced by short circuit
- The internal impedance of an ideal current source is ∞ → replaced by an open circuit



ELECTRICAL NETWORK



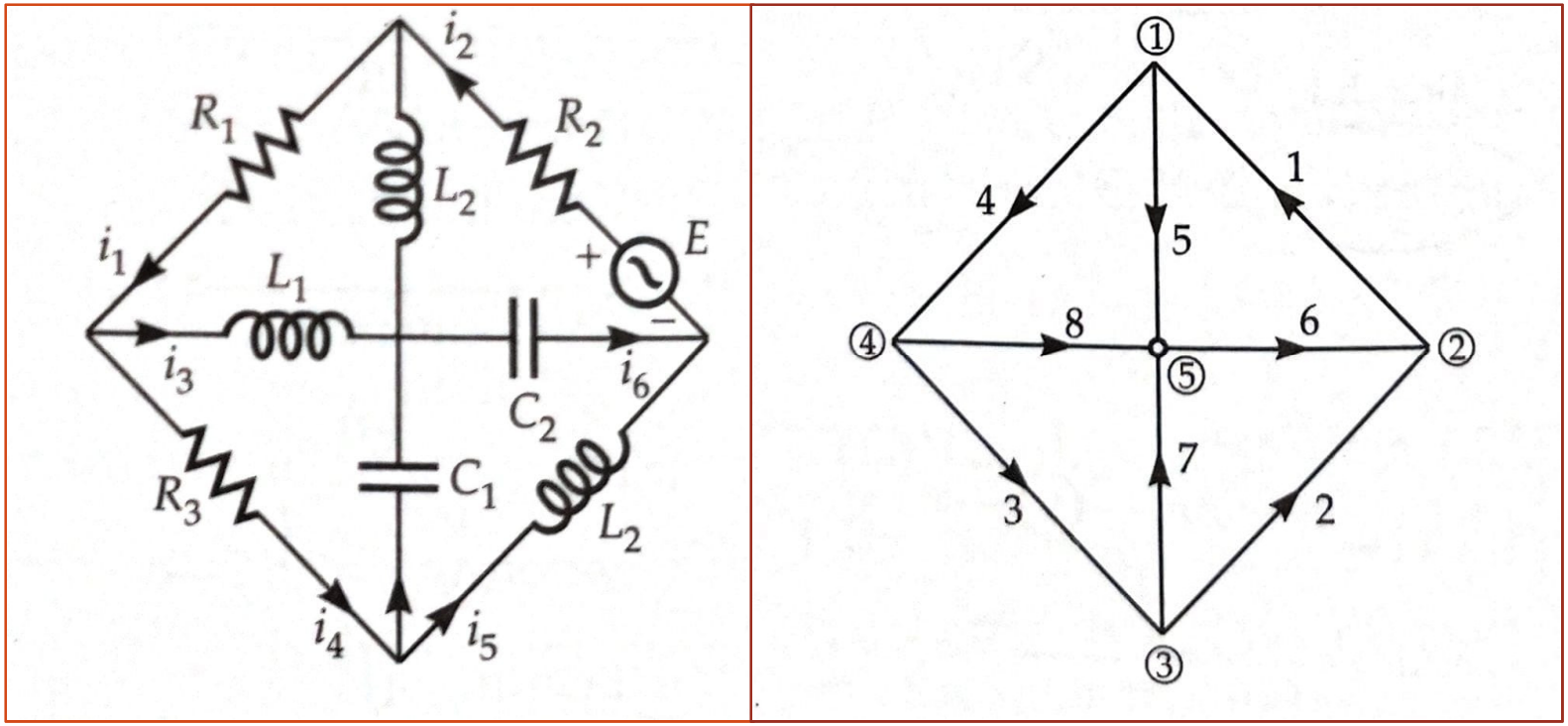


UNDIRECTED GRAPH

DIRECTED GRAPH

Note: A graph whose branches are oriented is called directed or oriented graph

DRAW THE DIRECTED GRAPH OF THE GIVEN ELECTRICAL NETWORK



ELECTRICAL NETWORK **DIRECTED GRAPH**

Important Terminology Related To Graph Theory

- **Rank:** The rank of a graph is (n-1) where n is the number of nodes of the graph.
- **Subgraph:** A subgraph is subset of the graph.
- **Proper Subgraph:** A subgraph is said to be proper if it consists of branches and nodes which is less than the original the original graph
- **Path:** A path is a subgraph consisting of an ordered sequence of braches having the following properties:-
    1. All but two of its nodes, called **internal nodes**, there are incident exactly two branches of the subgraph.
    2. At each of the remaining two nodes called **terminal nodes**, there is incident exactly one branch of the subgraph

- **Circuit/Loop**: A circuit or loop is a subgraph of a graph, at each node are incident exactly two branches of the subgraph. Thus, if two terminal nodes of a path coincide, the result will be a loop.

Properties of Loop/Circuit

1. **The maximum number of branches in a loop will be equal to the number of nodes**
2. **There are exactly two paths between any pair of nodes in a circuit**
3. **There are at least two branches in a circuit**

- **Tree:** A tree is a sub graph containing all the nodes of the graph but containing no loops. A graph has many trees.
- **Co-tree:** If we subtract a tree from a graph we will get co-tree. A co-tree may contain loops.
- **Twig:** Branches of a tree is called twig.
- **Link:** Branches of a co-tree is called link.

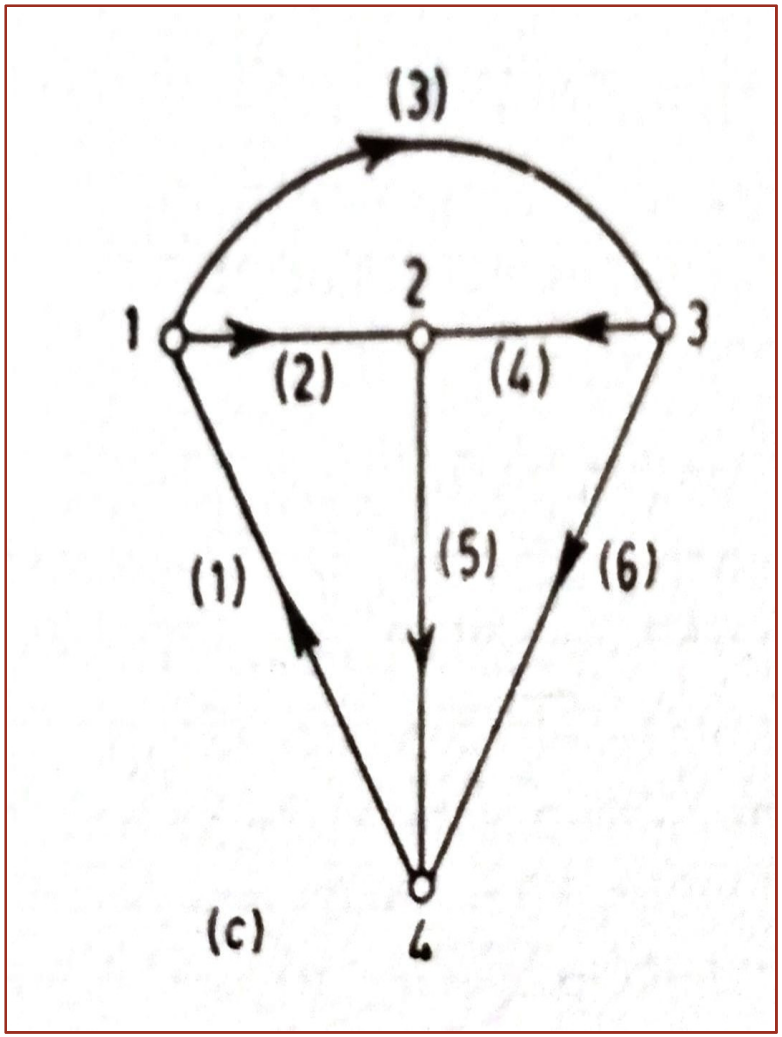
If a graph has b number of branches and n number of nodes then

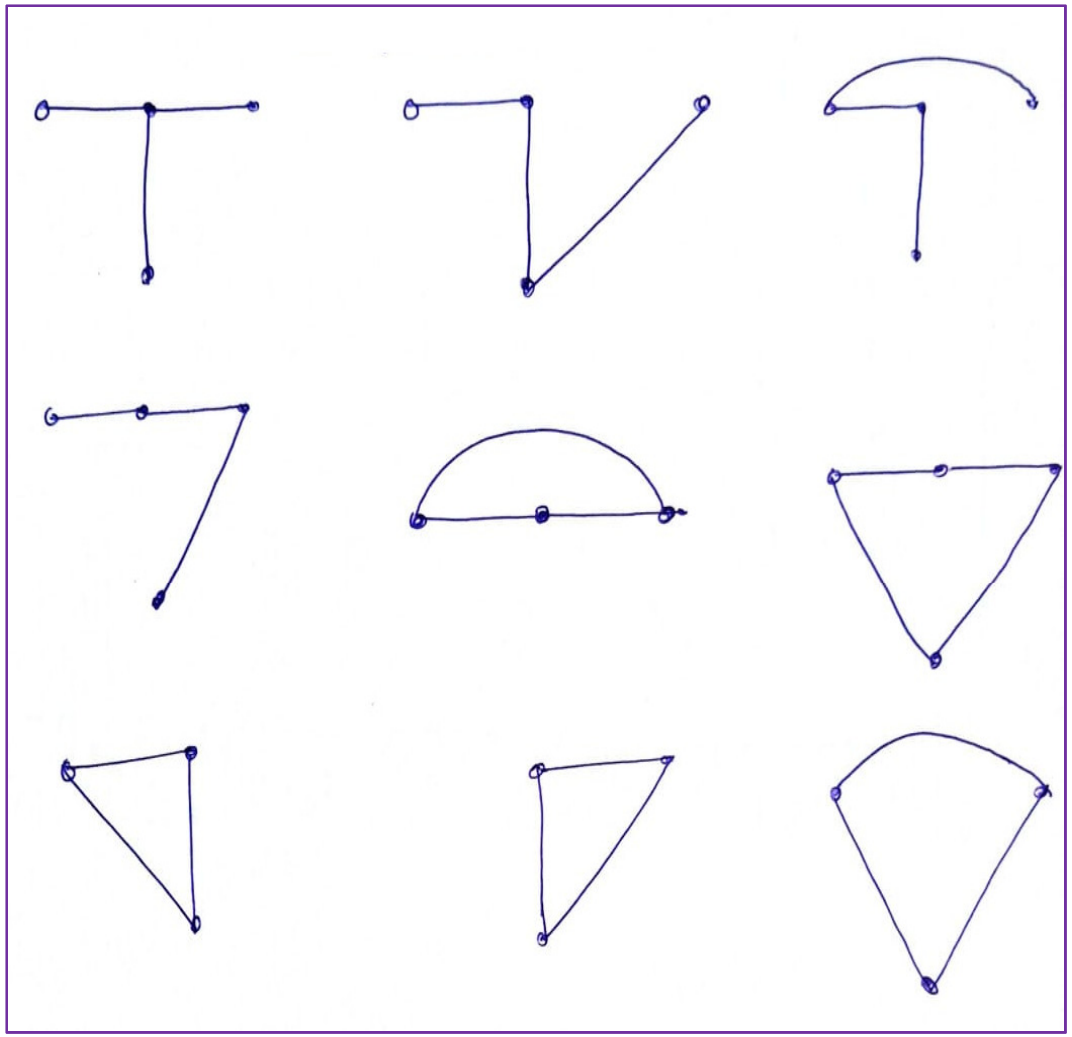
1. Number of branches present in its tree is (n-1) or a tree has (n-1) number of twigs
2. Number of branches present in its co-tree is (b-n+1) or co-tree has (b-n+1) number of links

Properties of Trees

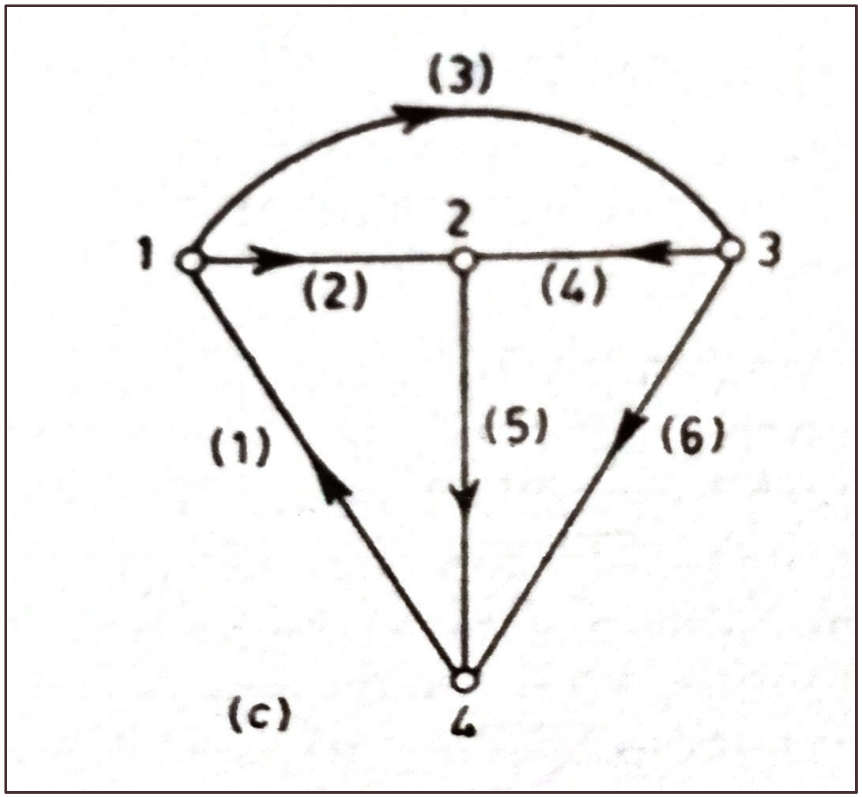
1. A connected subgraph of a connected graph is a tree if there exists only one path between any pair of nodes in it. Conversely, in a tree, there exists one and only one path between any pair of nodes.
2. Every connected graph has at least one tree.
3. The number of terminal nodes or end vertices of every tree are two.
4. A connected subgraph of a connected graph is a tree if there exists all the nodes of the graph.
5. Each tree has $(n-1)$ branches, where n is the number of nodes of the tree.
6. The rank of a tree is $(n-1)$. This is also the rank of the graph to which the tree belongs.

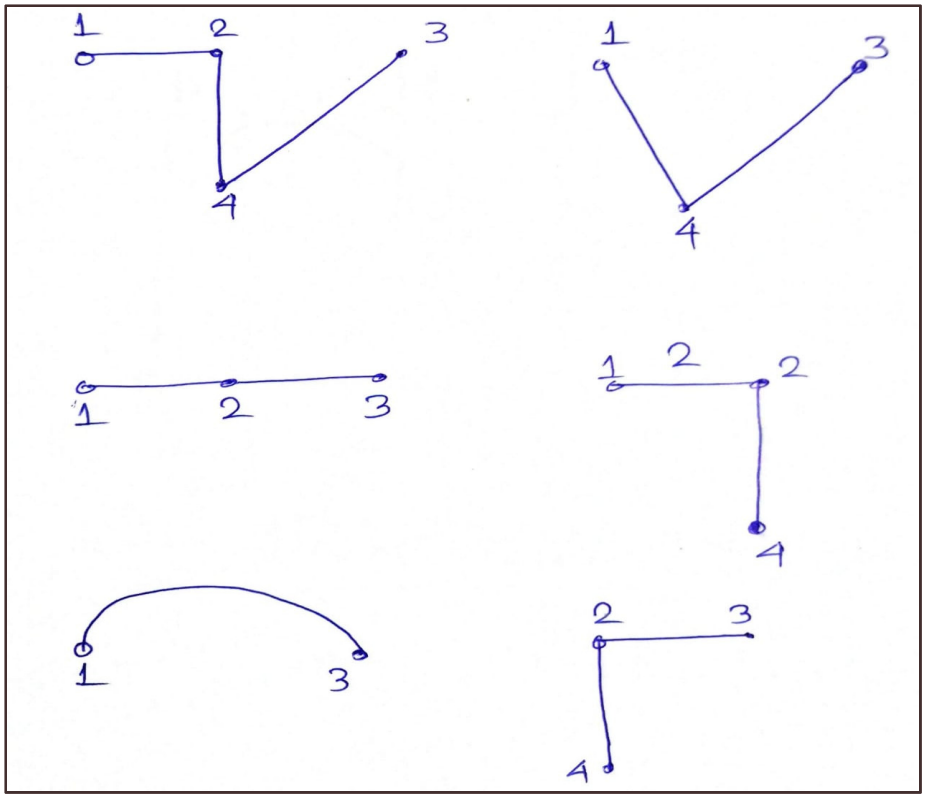
Subgraph



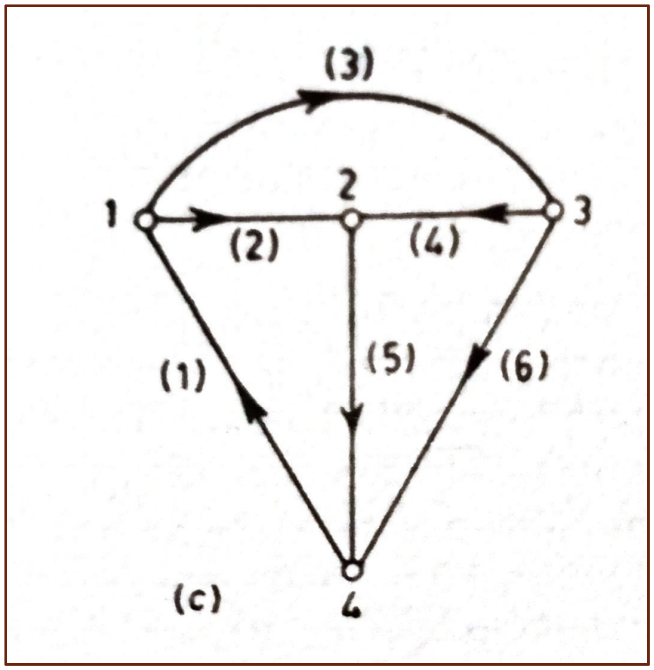


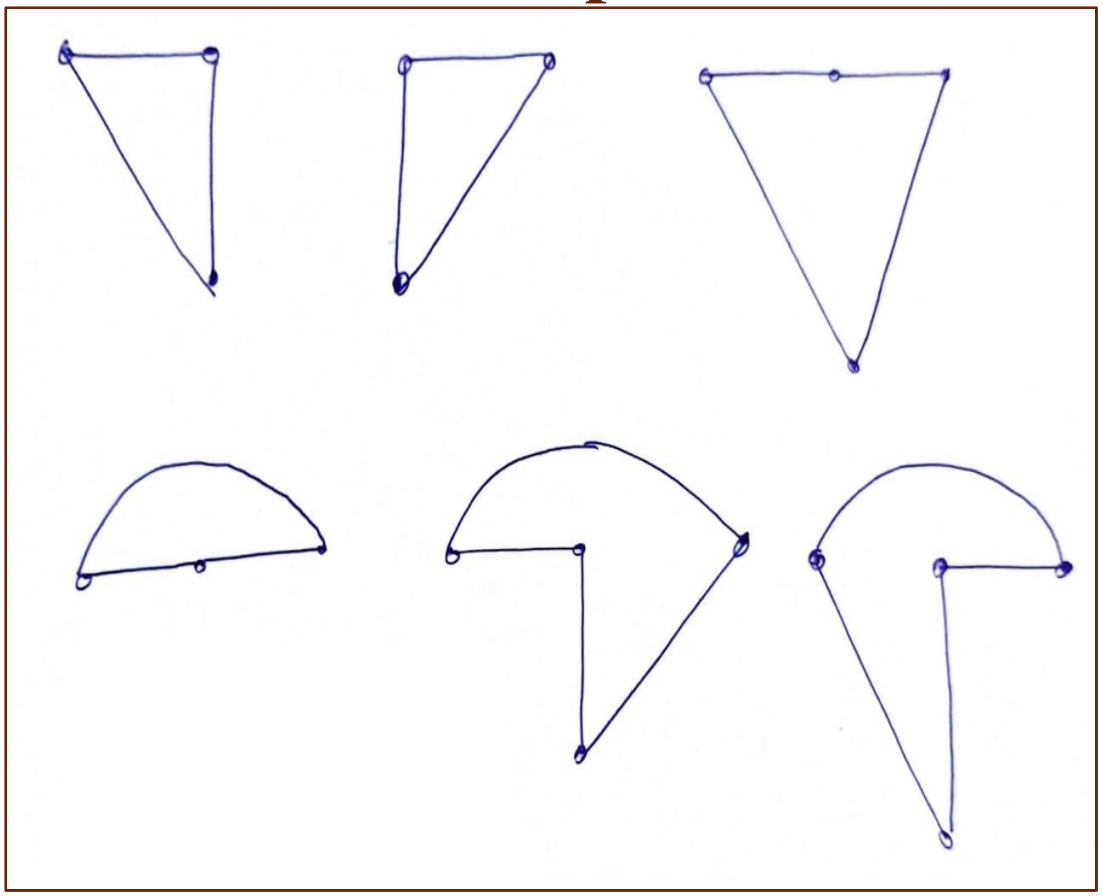
Path



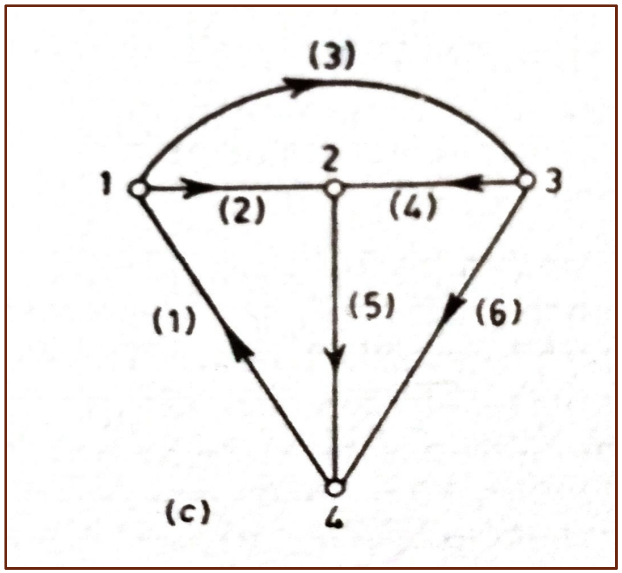


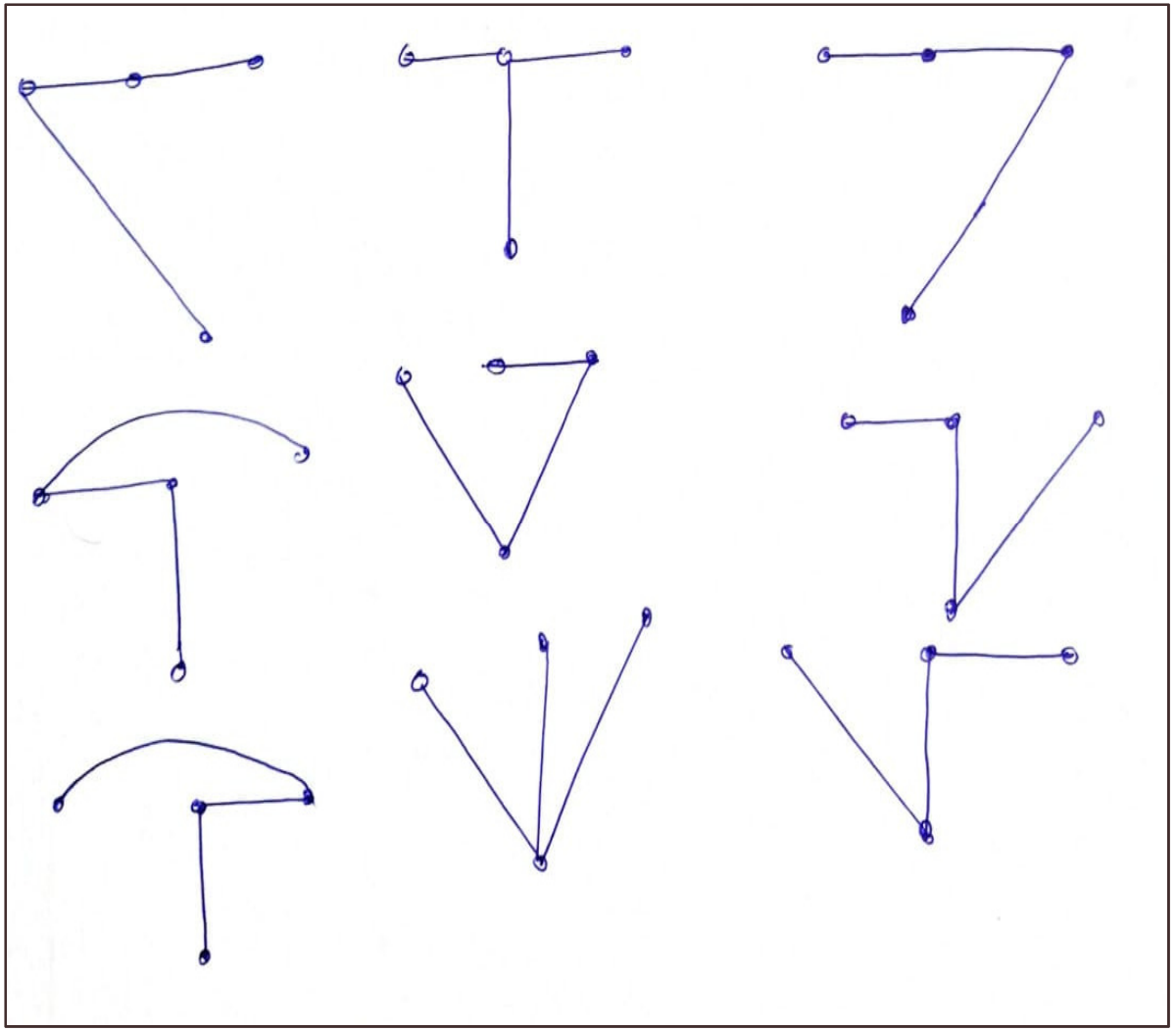
Loop





Tree





Tree & Co-tree