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Graphs

Introduction:-

Graph is a non linear data structure.
For example:- Map.

A graph contains a set of points known as nodes (or vertices) and set of links known as edges (or Arcs) which connects the vertices.

Graph Terminology:-

1. **Vertex**:- An individual data element of a graph is called as Vertex.

2. **Edge**:- An edge is a connecting link between two vertices.

Edges are of three types:-

1) Undirected edge:- An undirected edge is a bidirectional edge.

2)

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Unit :-1

Combinatorical Structure : Graph Theory Basics

1.1:- Basic Terminology of graph

1.2: Simple Graph

1.3 Degree of Vertex

1.4 Degree Sequence of Graph

1.5 First Fundatmental Theorem of graph

1.6 Incident Matrix and Adjecent Matrix

1.7 Trees : 1.7.1 Trees & their properties
1.7.2 Binary Tree
1.7.3 Complete Binary Tree
1.7.4 Full Binary Tree
1.7.5 Binary search Tree

Unit :- 2

Principals of Counting

2.1 :- Principle of Inclusion and Exclusion

2.2:- Generalizing Inclusion - Exclusion Priciples

2.3:- Deranements - Nothing is in right place

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2.4 :- Rook Polynomials

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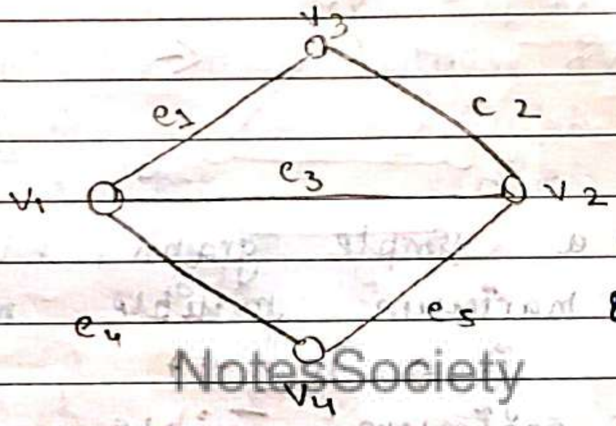
Unit Model:- Combinational Structures

1. Graph: The pictorial representation of object which are connected by link is known as Graph.

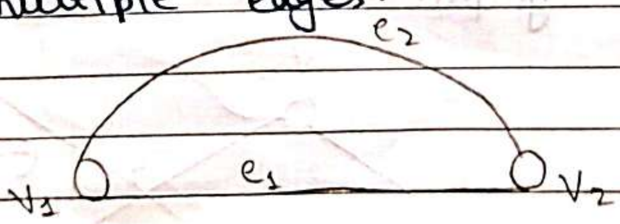
→ Objects are known as vertices.

→ Links are known as edges



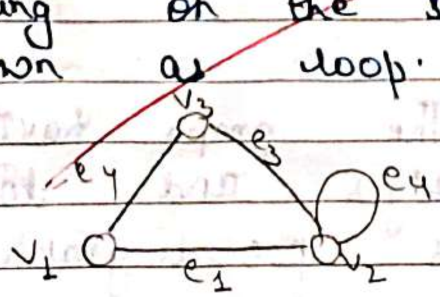
vertices = $\{v_1, v_2, v_3, v_4\}$
Edges = $\{e_1, e_2, e_3, e_4, e_5\}$

2. Parallel/Multiple edges: If between any pair of vertices, there are more than one edge. The edges are known as parallel/multiple edges.



Parallel edge = $\{e_1, e_2\}$

3. Loop: The edge starting from vertices, ending on the same vertices is known as loop.

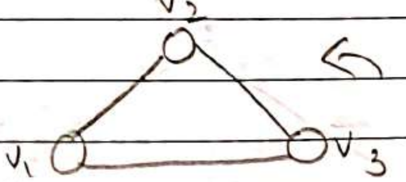


Loop = $\{e_4\}$

4) Types of Graphs :-

On the basis of parallel edge and loop :-

a) Simple graph :- The graph without any parallel edge and loop is known as simple graph.

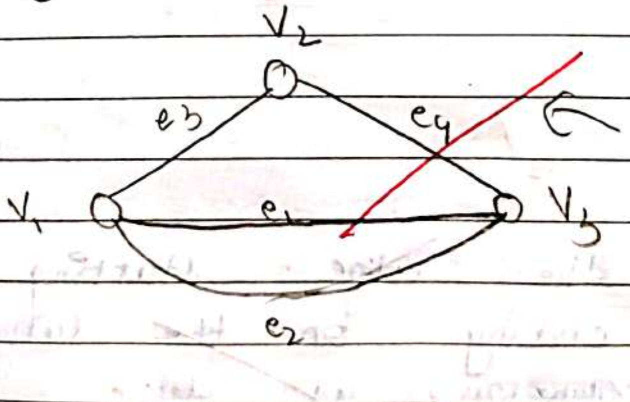


Simple graph

Note :- In a simple graph, with n vertices the maximum possible number of edge is $\Rightarrow \frac{n(n-1)}{2}$

Eg :- The maximum possible number of edges :- $n(n-1)/2 = 6/2 = 3$.

b) Multiple graph :- The graph having multiple edges, is known as multiple graph.



Multiple graph

c) Pseudograph :- The graph having multiple edges and loop is known as pseudograph.

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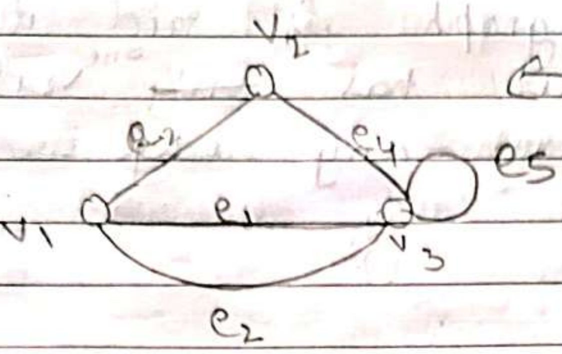
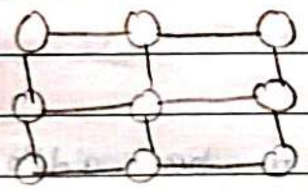
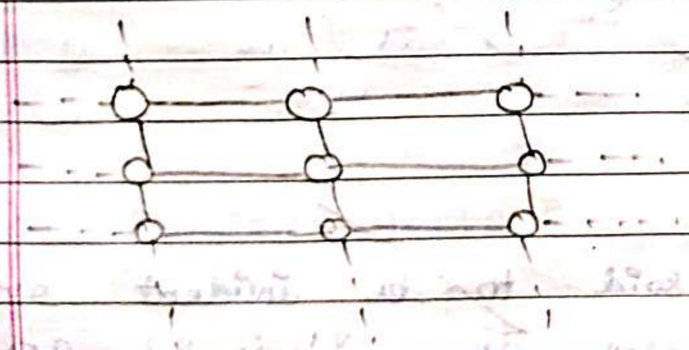


Pseudo Graph

d) Finite & Infinite Graph:- A graph is having finite number of vertices and edges, is known as finite graph & a graph is having infinite number of verties & edges, is known as infite graph.

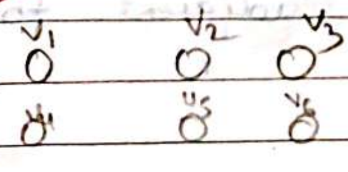


Finite graph



Infinite graph

e) Null graph:- A graph is said to be null, if it has any number of verties without edges.



Null graph

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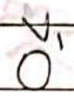
f) Trivial:- A graph is said to be trivial, if it has ~~only~~ one verticale only, without any edge.

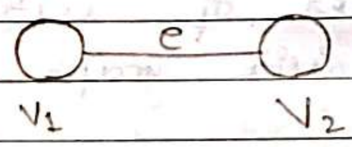


5) Adjancey:-

There are two types of adjancencies:-

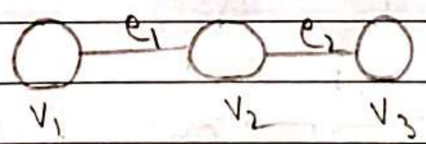
a) Adjacent Vertices:-

Two vertices are said to be adjacents, if they have one edge in common.



b) Adjacent Edge:-

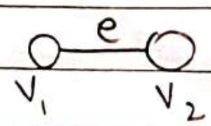
Two edges are said to be adjacent if they have one vertex in common.



6) Incidence:-

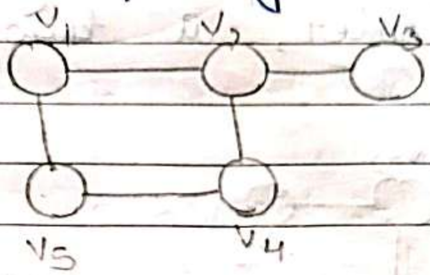
An edge is said to be incident on vertices (V_1 & V_2). If V1 & V2 are adject by e.

While neighbourhood of vertices v is set of all vertices which are adjacent to be V.



7) Degree of vertex :-

The degree of vertex v in a graph G(v,e) is the number of edges of edges incident on it.

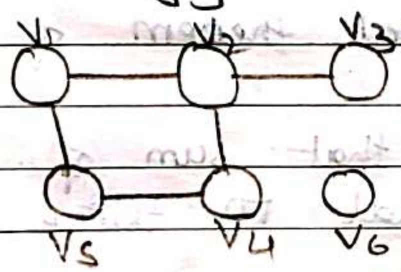


$dg(V_1) = 2$
$dg(V_2) = 3$
$dg(V_3) = 1$
$dg(V_4) = 2$
$dg(V_5) = 2$

a) Pendant vertex :-

The vertex whose degree is one, is called pendant vertex.

Vertex V_3 in fig is pendant vertex.



$dg(V_3) = 1$

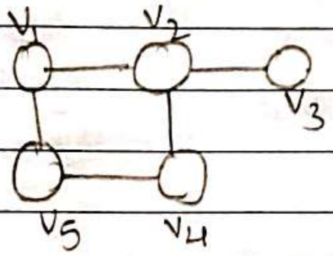
b) Isolated vertex :-

The vertex whose degree is zero, called isolated vertex.
vertex V6 in fig is Isolated :- (above)

$\therefore dg(V_6) = 0$.

8) Degree sequence of a graph:-

The set of degree of all the vertices of all the graph are arranged in increasing or decreasing order, is known as degree seq. of a graph.



Degree seq (increasing)

1 2 2 2 3

OR

Degree seq (decreasing)

3 2 2 2 1

9) Hand shaking Theorem:-

(Fundamental theorem of graph theory).

a) It said ~~graph~~ that sum of degree of all vertices is equal to twice of number of its edges.

$\Sigma \text{degree}(V) = 2m$

where m is no. of edges.

$\Sigma\, 0 + 1 + 2 + 2 + 3 = 2m$

$\therefore m = \cancel{8}\ 4.$

Verify the Handshaking theorem for a given graph.

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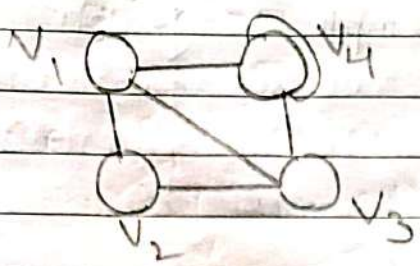


$dg(V_1) = 3 \quad dg(V_3) = 3$

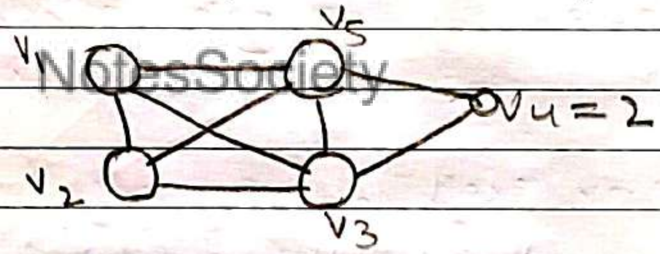
$dg(V_2) = 2 \quad dg(V_4) = 4$

$\Sigma \; 3 + 2 + 3 + 4 = 2m$

$12 = 2m$

$6 = m$

→ Verify the handshaking theorem for a given graph.



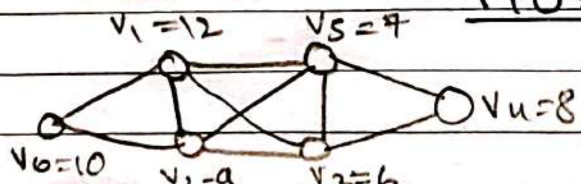
$V_1 = 3, \; V_5 = 6, \; V_2 = 4, \; V_3 = 5$

$V_4 = 2$.

$\Sigma \; 3 + 6 + 4 + 5 + 2 = 2m$

$20 = 2m$

$\boxed{10 = m}$



$V_1 = 12, \; V_2 = 9, \; V_3 = 6, \; V_4 = 8, \; V_5 = 7,$

$V_6 = 10$

$= \Sigma \; 12 + 9 + 6 + 8 + 7 + 10 = 2m$

$52 = 2m$

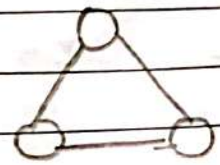
$26 = m$.

① **Note** :- In a simple graph, with n vertices, the maximum number of possible edges is :- $n(n-1)/2$.

Eg.1 $n=3$

Find the maximum po. edges.

$= \frac{3(3-1)}{2}$

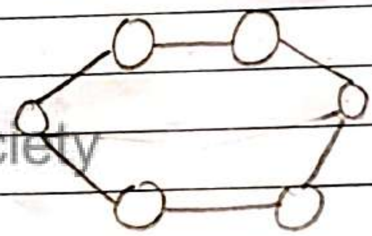


$= 3$.

Eg.2 $n=4$ (find max p. edges).

$\frac{4(4-1)}{2}$

$= 6$.



* $n=5$ (find max. p. edges)

② **Note** :- In simple graph with 'n' vertices, the maximum possible number of graph is constructed.

formula :- $2^{n(n-1)/2}$.

Eg.1 If $n=3$, then possible max no. of graph.

$\Rightarrow 2^{3(3-1)/2}$

$= 2^3$

$= 8$.

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$\rightarrow n = 6$

$2^{6(6-1)/2}$

$= 2^{15} = 32,768$

③ **Note:-** The number of edges in a graph is known as it size, while the no. of vertices is known as its order.

⑩ Adjacent Matrix and Incident Matrix

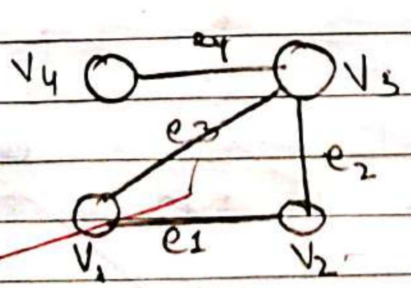
The matrix of the form, $a_{ij} = \begin{cases} 1 & v_i \text{ is adjacent to } v_j \\ 0 & \text{otherwise} \end{cases}$

is known as adjecent matrix, while the matrix of the form,

$a_{ij} = \begin{cases} 1 & e_i \text{ is incident to } v_j \\ 0 & \text{otherwise.} \end{cases}$

is known as incident matrix.

Find the matrix of incidence and adjacent



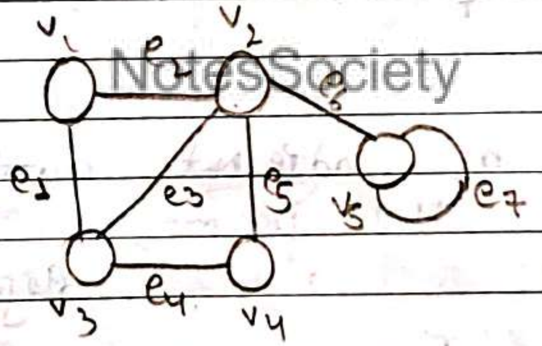
$$\begin{array}{c} \\ v_1 \\ v_2 \\ v_3 \\ v_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{bmatrix} 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \end{array}$$

incidence

The matrix :-

$$\begin{array}{c} v_1 \\ v_2 \\ v_3 \\ v_4 \end{array} \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

adjacent



Incidence:-

$$\begin{array}{c} \\ v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{array} \begin{array}{c} \begin{array}{ccccccc} e_1 & e_2 & e_3 & e_4 & e_5 & e_6 & e_7 \end{array} \\ \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix} \end{array}$$

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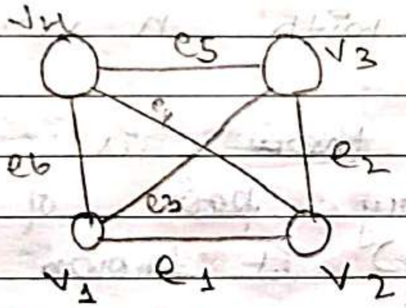
adjacent

	V_1	V_2	V_3	V_4	V_5
V_1	0	1	1	0	0
V_2	1	0	1	1	1
V_3	1	1	0	1	0
V_4	0	1	1	0	0
V_5	0	1	0	0	1



Incidence:-

	e_1	e_2	e_3	e_4	e_5	e_6
v_1	1	0	1	0	0	1
v_2	1	1	0	1	0	0
v_3	0	1	1	0	1	0
v_4	0	0	0	1	1	1

Adjacence:-

	V_1	V_2	V_3	V_4
v_1	0	1	1	1
v_2	1	0	1	1
v_3	1	1	0	1
v_4	1	1	1	0

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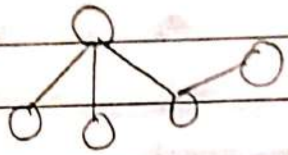
Trees:

a) A graph without cycle, is known as a tree.

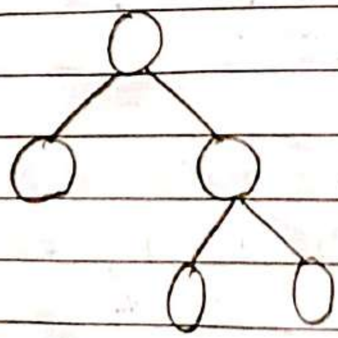


Tree.

b) Result :-

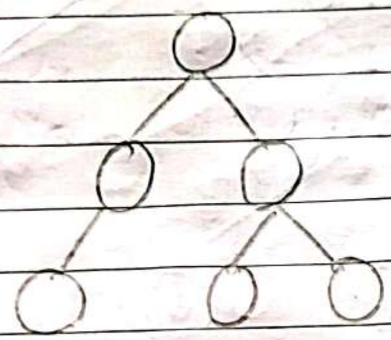
- In a tree with n vertices, there are (n-1) edges.
- In a tree there is only one path between every pair of vertices.
- The graph (G) is known as tree, if there is one and only one path between every pair of vertices.

c) • Rooted Tree :- The tree is said to be a rooted tree, if we assign one of the vertices as a root and the rest are coming out from this.



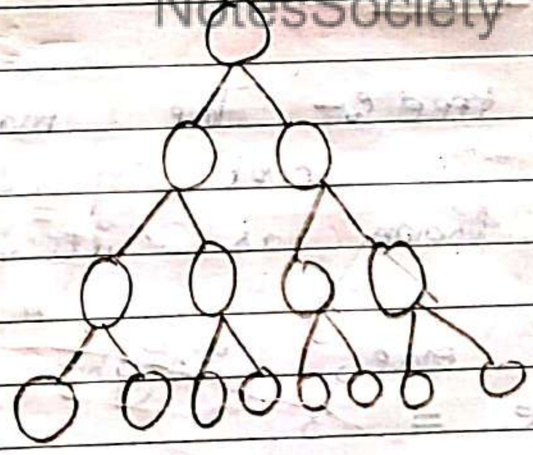
Rooted tree.

• Binary tree :- A rooted tree is said to be binary tree, if its out degree is less or equal to 2.
i.e., (≤ 2), i.e. 0, 1, 2.



Binary tree

• Complete binary tree :- A binary tree is said to be complete, if the out degree of every vertex is exactly equal to 2.



Complete binary tree.

d). Level of a vertex :- The level of vertex in a rooted tree is its distance from root.

(PTO)

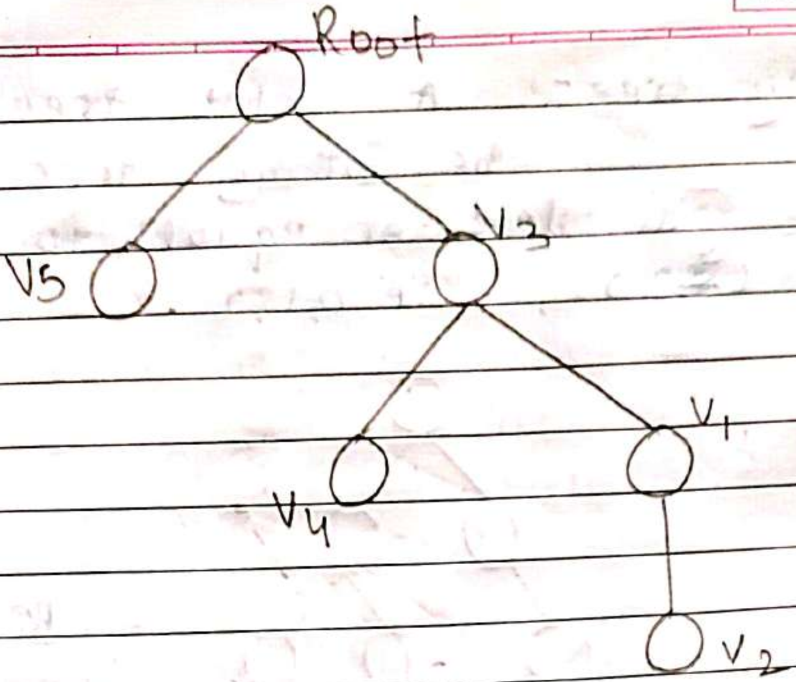


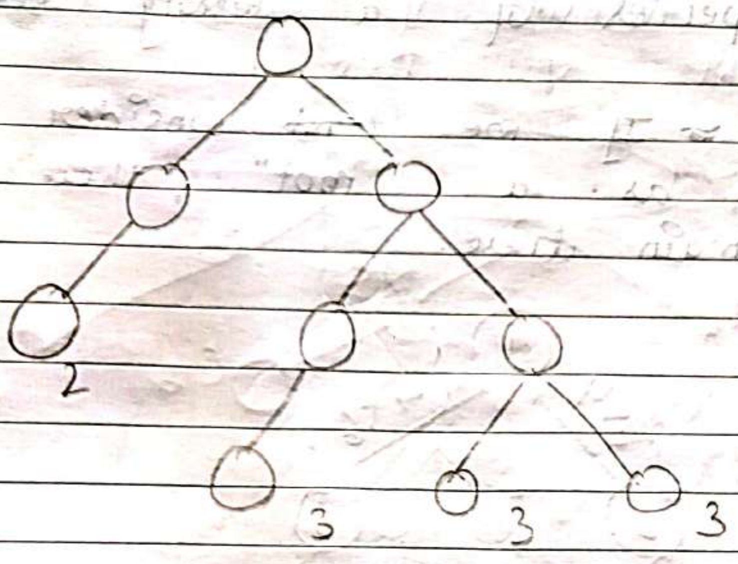
Figure 1 :-

Level of V1 = 2
Level of V2 = 3
Level of V3 = 1
Level of V4 = 2
Level of V5 = 1

- Height of a tree :- The maximum of a level of vertices in a rooted tree is known as its height of a tree.

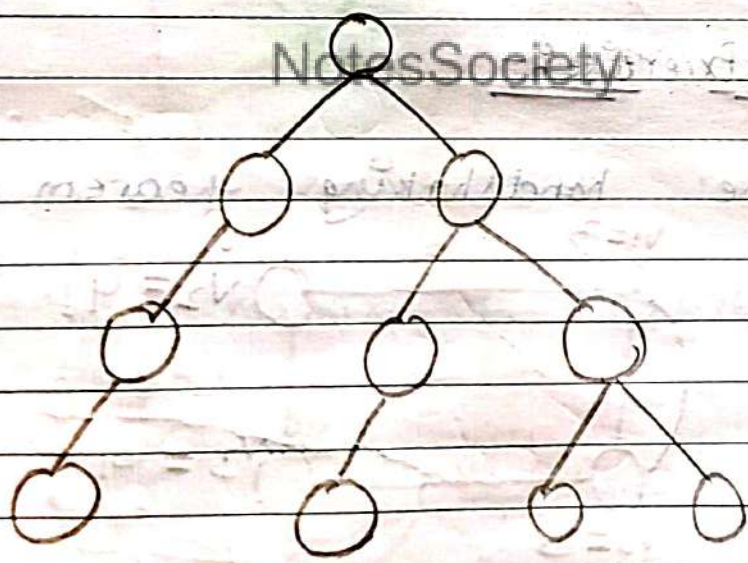
In figure one, height of a rooted tree = 3.

- Balanced tree :- A rooted tree is said to be a balanced tree if its height is 'h' or (h-1).



Balanced tree.

• Full binary tree :- A balanced tree is said to be full binary tree if its height is exactly "h"

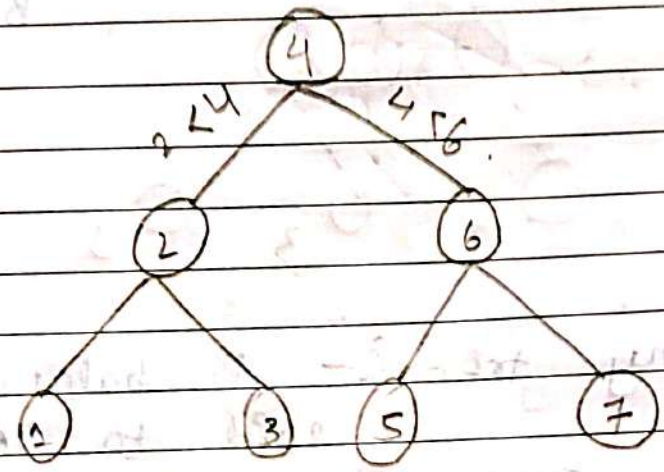


Full binary tree.

Binary Search Tree :- A binary search tree (BST) is a binary tree where every node in the left sub-tree is less than the root and every node in the right sub-tree is of a value greater than the root.

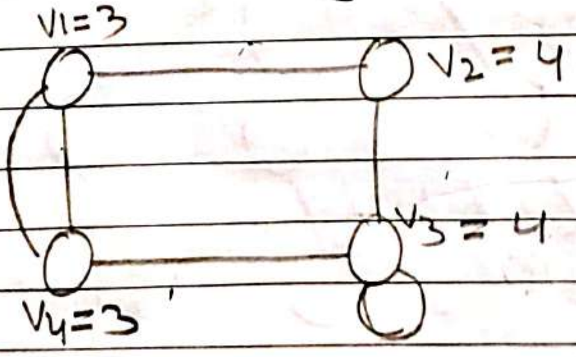
The properties of a binary search tree are:

↳ Recursive ; If we ~~const~~ consider every node as a "root", these properties which remain true.



Assignment / Excersise :-

1) Verify the handshaking theorem.



dg. $V_1 = 3$

dg. $V_2 = 4$

dg. $V_3 = 4$

dg. $V_4 = 3$

$\Sigma\ v_1 + v_2 + v_3 + v_4 = 2m$

$3 + 4 + 4 + 3 = 2m$

$14 = 2m$

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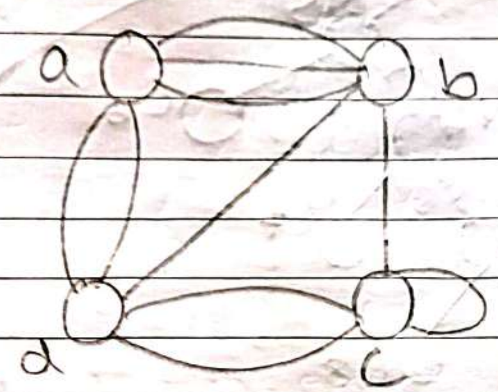
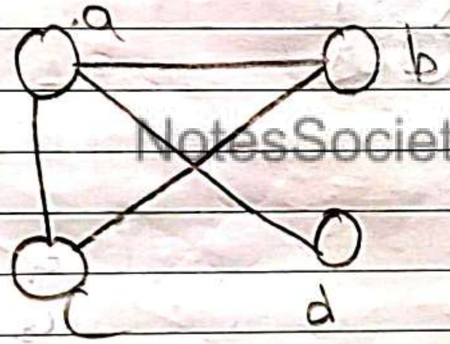
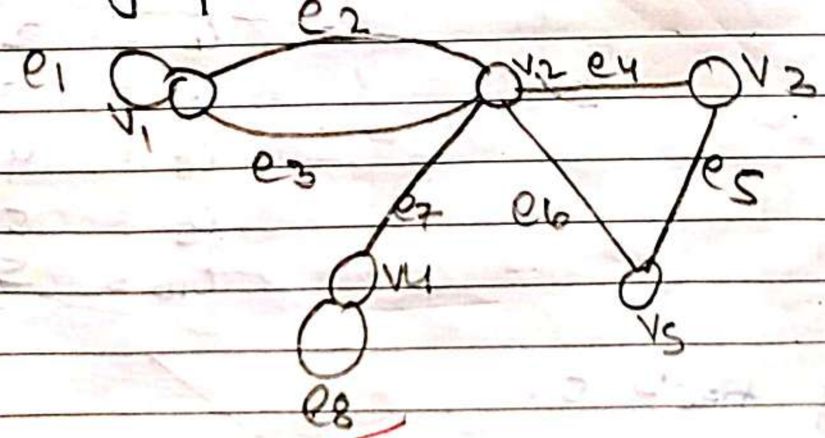
$\boxed{7=m}$

i) Find the adject matrix for the following graph.

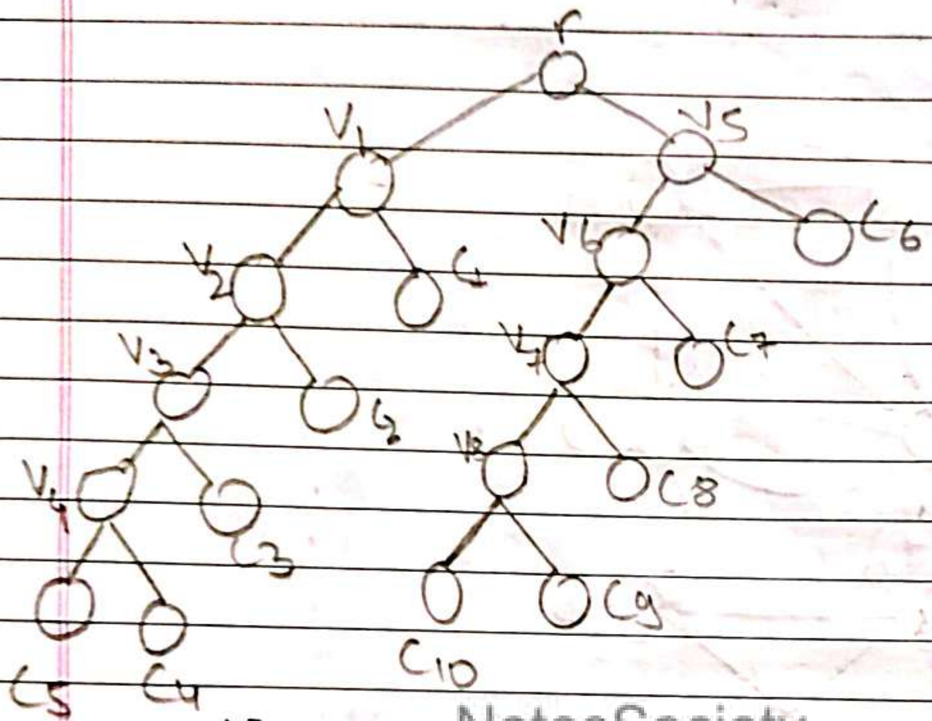




ii) Find the matrix of incidence for the given graph.



IV) Find the level of each vertex and the height of tree.



LEVELS.

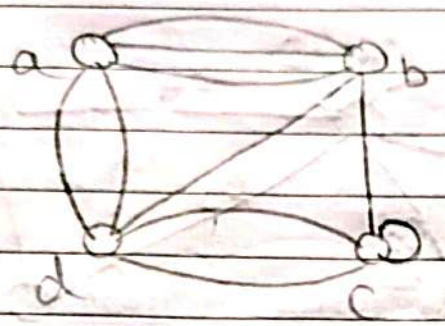
NotesSociety

$V_1 = 1$	$C_1 = 2$
$V_2 = 2$	$C_2 = 3$
$V_3 = 3$	$C_3 = 4$
$V_4 = 4$	$C_4 = 5$
$V_5 = 1$	$C_5 = 5$
$V_6 = 2$	$C_6 = 2$
$V_7 = 3$	$C_7 = 3$
$V_8 = 4$	$C_8 = 4$
	$C_9 = 5$
	$C_{10} = 5$.

Height of tree :- 5.

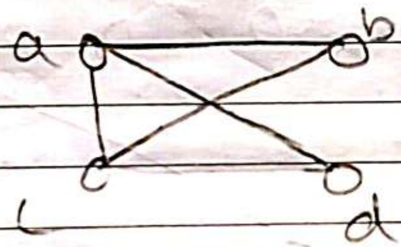
2) adjacent matrix.

i)



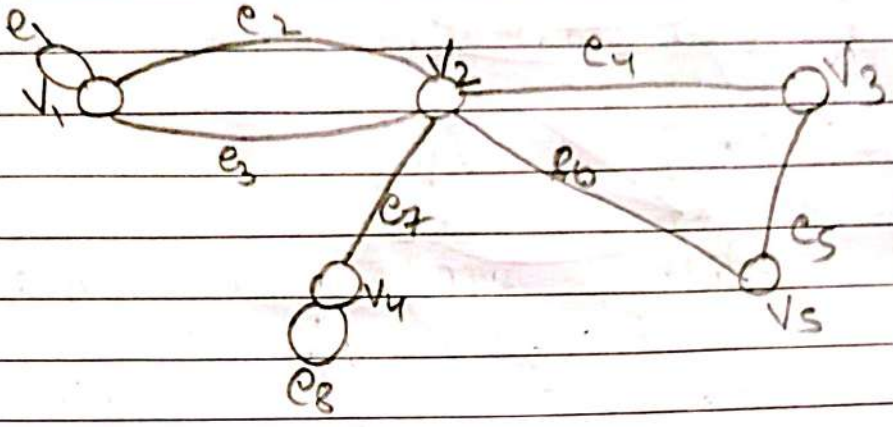
	a	b	c	d
a	0	1	0	1
b	1	0	1	1
c	0	1	1	1
d	1	1	1	0

ii)



	a	b	c	d
a	0	1	1	1
b	1	0	1	0
c	1	1	0	0
d	1	0	0	0

3) Incidence matrix.



	e_1	e_2	e_3	e_4	e_5	e_6	e_7	e_8
V_1	1	1	1	0	0	0	0	0
V_2	0	1	1	1	0	1	1	0
V_3	0	0	0	1	1	0	0	0
V_4	0	0	0	0	0	0	1	1
V_5	0	0	0	0	1	1	0	0

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Module-II

Principle's of Countings

① Set Theory

ⓐ Set theory:- collection of well defined objecet is known as set.

eg:- $A = \{x : x$ is a set of even numbers less than $10\}$ (set builder form)

$B = \{2, 4, 6, 8\}$ (Roster Form) (✓)

$C = \{x : x$ is a set of cremenal's $\}$ (✗)

ⓑ Types of sets

(i) Finite and infinite sets:- The set who elements are finite is known as a finite set otherwise infinite set.

eg:- $F = \{x : x$ is a set of odd numbers less than or equal to $1000\}$

$G = \{x : x$ is a set of real numbers$\}$

(ii) Null set and universal set:- The set which doesn't contain any element is known as Null set. It is denoted as $\{\phi\}$ or its also known as $\{\}$ (empty set).

If we have more that one set than the set containing all other sets known as universal set. It is denoted by U.

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(iii) Subset :-

Consider

U' = {1, 2, 3, 4, 5, 6, 7, 8, 9}

A = {4, 5, 6}

B = {6, 7, 8, 9}

then A and B are said to be subsets of U because all the elements of A & B are containing in elements of U.

(iv) Operations on Sets :-

There are several operations for sets, some of them are :-

a) Union of sets

b) Intersection of sets

c) Differencce of sets

eg :- let A = {x : x is a set of natural numbers less than 14}

B = {x : x is a set of even numbers less than or equal to 20}

∴ A∪B

In Roster form :-

A = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13}

B = {2, 4, 6, 8, 10, 12, 14, 16, 18, 20}

∴ A∪B = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18, 20}

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$A \cap B = \{2, 4, 6, 8, 10, 12\}$

In set Builder form:-

$A \cup B$ - { x : x is a set of natural numbers less than or equal to 14 and even numbers between 16 to 20 }

$A \cap B$ = { x : x is a set of even numbers less than or equal to 12 }

(v) Disjoint sets:- Two sets A and B are said to be Disjoint sets, if there ~~are~~ intersection is a Null set

eg:- A = { x : x is a set of odd numbers less than or equal to 100 }

B = { x : x is a set of even no. less than or equal to 100 }.

∴ A & B are Disjoint sets.

∴ $A \cap B = \{\phi\}$.

(vi) Complement of a set:- The complement of set A is a set which contains all those elements which are not contained in A as compare to universal set.

eg:- $U = \{a, b, c, d, e, f, g\}$

$A = \{c, d\}$

$A^c = \{a, b, e, f, g\}$

(vii) Cardinality of a set:- It is defined as no. of elements contained in a

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$A \cap B = \{2, 4, 6, 8, 10, 12\}$

In set Builder form:-

$A \cup B$ = { x : x is a set of natural numbers less than or equal to 14 and even numbers between 16 to 20 }

$A \cap B$ = { x : x is a set of even numbers less than or equal to 12 }

(v) Disjoint sets:- Two sets A and B are said to be Disjoint sets, if there ~~are~~ intersection is a Null set

eg:- A = { x : x is a set of odd numbers less than or equal to 100 }

B = { x : x is a set of even no. less than or equal to 100 }.

∴ A & B are Disjoint sets.

∴ $A \cap B = \{\phi\}$.

(vi) Complement of a set:- The complement of set A is a set which contains all those elements which are not contained in A as compare to universal set.

eg:- $U = \{a, b, c, d, e, f, g\}$

$A = \{c, d\}$

$A^c = \{a, b, e, f, g\}$

(vii) Cardinality of a set:- It is defined as no. of elements contained in a particular set. It is denoted as n(A) or |A|.

② **Principle of Inclusion & Exclusion**

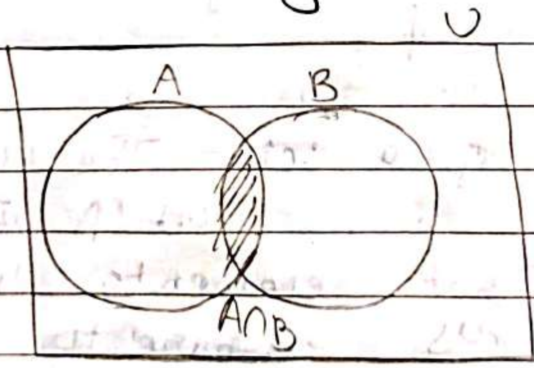
The principle of inclusion & exclusion is used for joint sets i.e, which are not disjoint sets.

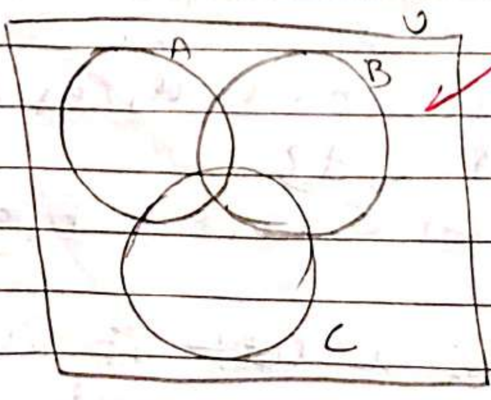
- For any two sets A & B :-

- $|A \cup B| = |A| + |B| - |A \cap B|$

- For any three sets A, B & C :-
- $|A \cup B \cup C| = |A| + |B| + |C| - |A \cap B| - |A \cap C| - |B \cap C| + |A \cap B \cap C|$

This principle can be explained by using venn diagram.





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Example 1 :- An organization wants to hire the staff in which he needs 30 Technical and 20 non Technical and 5 both which are Technical & Non-Technical. How many people are getting hired in total?

Sol^n :- Let T = Techical staff

N = Non-technical staff

$n(T) = 30$

$n(N) = 20$

$n(T \cap N) = 5$

$\therefore$ By Priciple of inclusion & exclusion we have :-

$n(T \cup N) = n(T) + n(N) - n(T \cap N)$

$n(T \cup N) = 30 + 20 - 5$

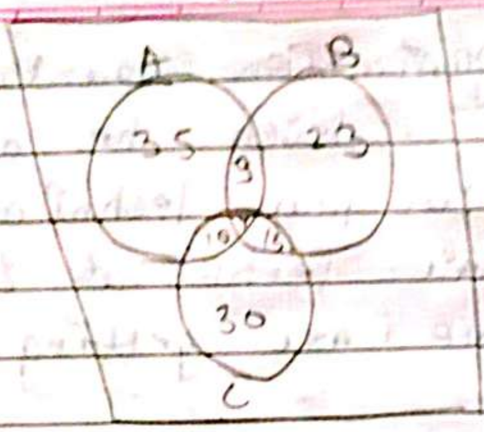
$n(T \cup N) = 45$

$\therefore$ Total staff hired = 45.

Example 2 :- There are 150 students in a party and there are three different brands A, B & C of drink out of which 58 students drink A, 49 drink B, 57 drink C, 14 drink A & C, 13 drink A & B, 17 drink B & C, 4 drink A, B & C. How many students drink none?

Method 1 :- $U = 150$

$U = 150$



$150 - 124$

$= 26.$

Method 2:-

By the principle of inclusion exclusion, we have:-

$$|A \cup B \cup C| = |A| + |B| + |C| - |A \cap B| - |A \cap C| - |B \cap C| + |A \cap B \cap C|$$

$$|A \cup B \cup C| = 164 - 40$$
$$= 124.$$

$$\therefore |A \cup B \cup C| = U - |A \cup B \cup C|$$
$$= 150 - 124 = 26.$$

Example 3:- 270 college students, 64 like brussel sprouts, 94 like broccoli, 58 like cauliflower, 26 like both brussel sprouts & broccoli, 28 like both brussel sprouts & cauliflower, 22 like both broccoli broccoli & cauliflower, 14 like all three vegetables. How many of them don't like any of the three vegetables?

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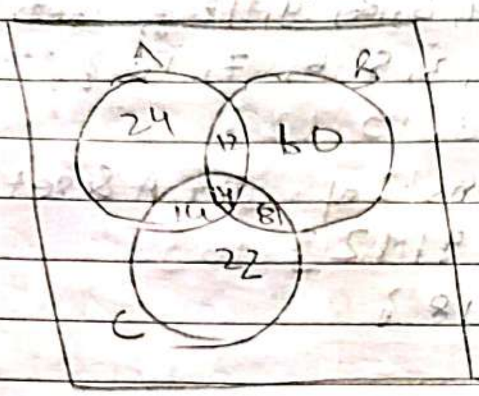
M1 :-

$U = 270$



$= 270 - 154$

$= 116.$

Method:-2

By the principle of Inclusion & Exclusion, we have

$$|A \cup B \cup C| = |A| + |B| + |C| - |A \cap B| - |A \cap C| - |B \cap C| + |A \cap B \cap C|$$

$$= 216 - 76 + 14$$

$$= 154$$

$\therefore$ $|A \cup B \cup C| = U - |A \cup B \cup C|$

$$= 270 - 154$$

$$= 116.$$

Examples :-

1) If $A = \{1, 4, 3, 7, 9, 12\}$, $B = \{1, 8, 3, 4, 7\}$. Find $A \cap B$.

$\rightarrow$ $A = \{1, 4, 3, 7, 9, 12\}$

$B = \{1, 8, 3, 4, 7\}$

$\Rightarrow$ $A \cap B = \{1, 3, 4, 7\}.$

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2. If set $A = \{2, 4, 6, 8, 9, 12\}$, set $B = \{1, 3, 5, 9, 15, 18\}$ and set $C = \{2, 3, 5, 6, 7, 10\}$, solve following:

i) Find intersections of set A & set B.

→ $A = \{2, 4, 6, 8, 9, 12\}$
$B = \{1, 3, 5, 9, 15, 18\}$

$\therefore A \cap B = \{9\}$

ii) Find intersection of set B & set C.

→ $B = \{1, 3, 5, 9, 15, 18\}$
$C = \{2, 3, 5, 6, 7, 10\}$

$\therefore B \cap C = \{3, 5\}$

iii) Find intersection of set A and set C.

→ $A = \{2, 4, 6, 8, 9, 12\}$
$C = \{2, 3, 5, 6, 7, 10\}$

$\therefore A \cap C = \{2, 6\}$

3. If $A = \{x, y, z\}$ and $B = \{\phi\}$. Find the intersection of two sets A and B.

→ $A = \{x, y, z\}$
$B = \{\phi\}$

$\therefore A \cap B = \{\}$

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Worksheet :-

1) State whether the following are True or False:-

a) If $A = \{5, 6, 7\}$ and $B = \{6, 8, 10, 12\}$; $A \cup B = \{5, 6, 7, 8, 10, 12\}$.
True.

b) If $P = \{a, b, c\}$ and $Q = \{b, c, d\}$; the P intersection $Q = \{b, c\}$.
True.

c) Union of two sets is the set of elements which are common to both the sets.
False.

d) Two disjoint sets have atleast one element in common.
False.

e) Two overlap sets have all the elements common.
False.

f) If two given sets have no elements common to both sets, the sets are said to be disjoint.
True.

g) If A and B are two disjoint sets then $A \cap B = \{\}$, the empty set. True.

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2) Let A, B and C be three sets such that:-

Set A = {2, 4, 6, 8, 10, 12}
set B = {3, 6, 9, 12, 15}
set C = {1, 4, 7, 10, 13, 16}

Find:-

a) {A ∪ B}:-
{2, 3, 4, 6, 8, 9, 10, 12, 15}.

b) {A ∩ B}:-
{6, 12}

c) {B ∩ A}:-
{6, 12}

d) {B ∪ A}:-
{2, 3, 6, 4, 9, 8, 12, 10, 15}

e) {B ∪ C}:-
{1, 3, 4, 6, 7, 9, 10, 12, 13, 15, 16.}

f) IS A∪B = B∪A?
True.

g) Is B∩C = B∪C?
False.

3) If A = {1, 3, 7, 9, 10}, B = {2, 5, 7, 8, 9, 10}, C = {0, 1, 3, 10}, D = {2, 4, 6, 8, 10}, E = {negative natural numbers} and F = {0}.

a) A∪B = {1, 2, 3, 5, 7, 8, 9, 10}
b) E∪D = {2, 4, 6, 8, 10}
c) C∪F = {0, 1, 3, 10}
d) C∪D = {0, 1, 2, 3, 4, 6, 8, 10}
e) B∪F = {0, [illegible], 2, 5, 7, 8, 9, 10}

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f) $A \cap B = \{7, 9, 10\}$

g) $C \cap D = \{10\}$

h) $E \cap D = \{\emptyset\}$

i) $C \cap F = \{0\}$

j) $B \cap F = \{\}$

k) $(A \cup B) \cup (A \cap B) = \{1, 2, 3, 5, 7, 8, 9, 10\}$

l) $(A \cup B) \cap (A \cap B) = \{7, 9, 10\}$

4) If $A = \{2, 3, 4, 5\}$, $B = \{c, d, e, f\}$, and $C = \{4, 5, 6, 7\}$, find:-

a) $A \cup B = \{2, 3, 4, 5, c, d, e, f\}$

b) $A \cup C = \{2, 3, 4, 5, 6, 7\}$

c) $(A \cup B) \cap (A \cup C) = \{2, 3, 4, 5\}$

e) Is $(A \cup B) \cap (A \cup C) = A \cup (B \cap C)$?

$\rightarrow A \cup (B \cap C) = \{2, 3, 4, 5\}$

$(A \cup B) \cap (A \cup C) = \{2, 3, 4, 5\}$

$\therefore$ True.

5) If $A = \{a, b, c, d\}$, $B = \{c, d, e, f\}$ and $C = \{b, d, f, g\}$, find :-

a) $A \cap B = \{c, d\}$

b) $A \cap C = \{b, d\}$

c) $(A \cap B) \cup (A \cap C) = \{b, c, d\}$

d) $A \cap (B \cup C) = \{a, b, c, d\} \cap \{b, c, d, e, f, g\} = \{b, c, d\}$

e) Is $(A \cap B) \cup (A \cap C) = A \cap (B \cup C)$?

$\rightarrow$ True

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