Essential of Promblem Solving

MODULE - I

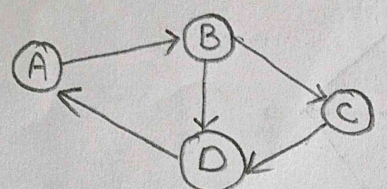
# GRAPH THEORY

1. Define a graph ?

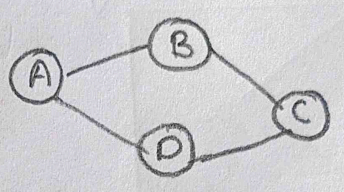
The closed loop is called as a graph.

There are differnt type of graphs :

1. Directed Graph : When the graph is represented by arrows then it is called directed graph.




Directed Graph



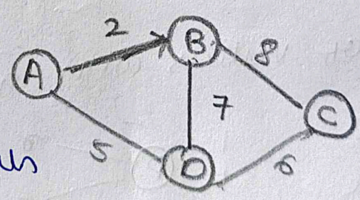

Undirected Graph

Graph :— A graph G is a mathematical representation consisting of two sets vertices (v) and edges (E)

2. Trivial Graph : A graph consisting only one vertex and no edge.

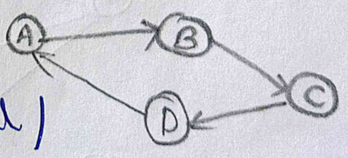
∵ Self loop graph : If the edge of graph starts at a vertex and ends at the same vertex then it is a loop.

3. Weighted graph : A graph in which the values are assigned to every edge of the graph




Weighted Graph

4. Cycle Graph : A graph which atleast contain one cycle which means the source and destination of graph are same.




Cycle Graph

- A cycle graph can be directional / undirectional ; weighted / unweighted

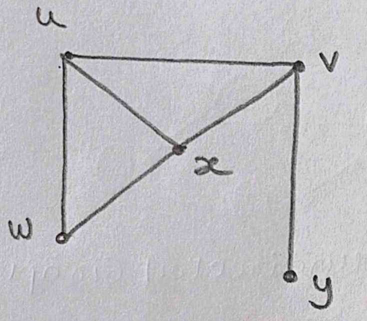
2. Define the conditions for two graphs $G_1$ and $G_2$ to be isomorphic with example ? Define the following

a. Weighted Graph  b. Complete Graph.

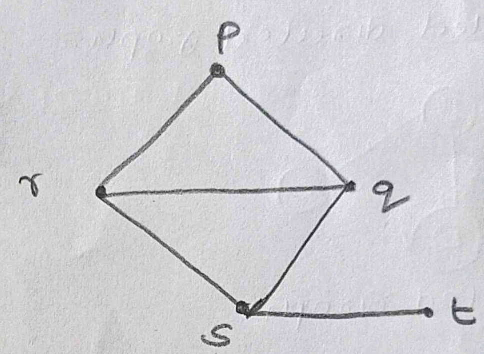
→ Now if $G_1$ and $G_2$ two graphs are isomorphic if only

- No. of vertices are same
- No. of edges are same
- An equal number of vertices with given degree
- Vertex correspondance and edge correspondance valid.

For example :




Graph $G_1$




Graph $G_2$

1. Number of vertices should be same

Graph $G_1$ vertices : 5

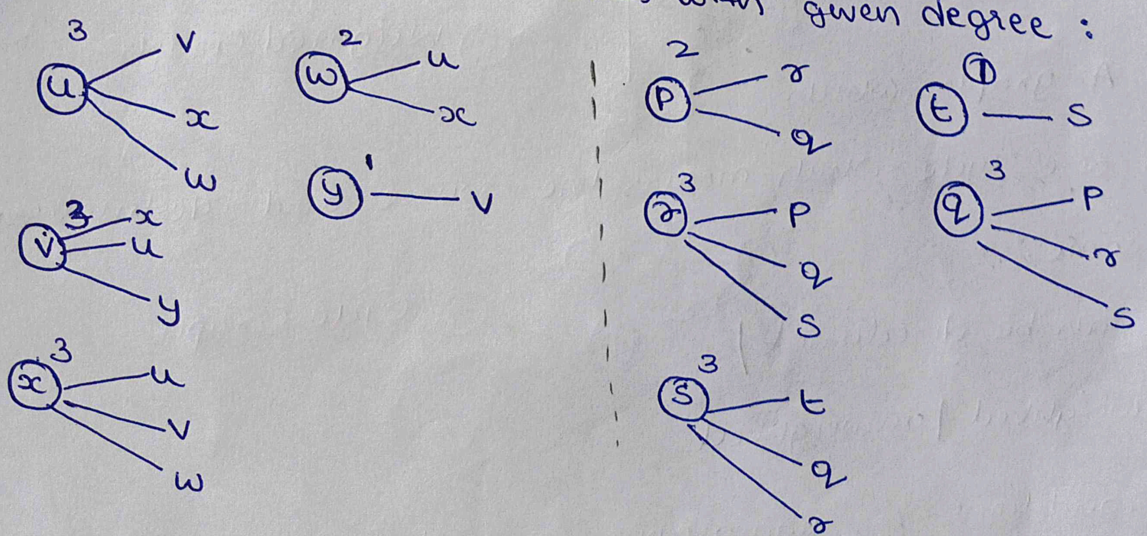
Graph $G_2$ vertices : 5

2. Number of edges are same

Graph $G_1$ : 6

Graph $G_2$ : 6

3. An equal number of vertices with given degree :




the equal no. of vertices with given degree are also same

4. equal vertex correspondance 4 edge correspondance :

($u \longleftrightarrow r$) ($w \longleftrightarrow p$)

($v \longleftrightarrow s$) ($y \longleftrightarrow t$)

($x \longleftrightarrow q$)

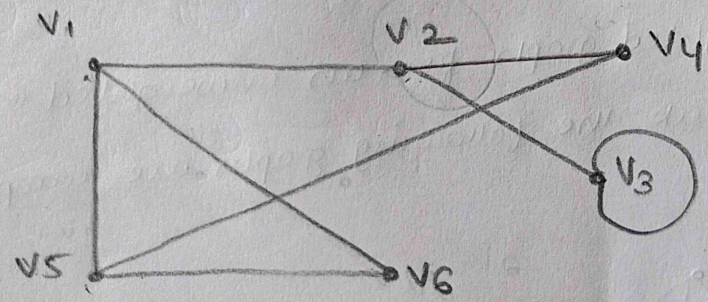
$\therefore$ Both the graphs $G_1$ and $G_2$ are isomorphic.

→ Complete Graph : A complete graph is a simple undirected graph in which every pair of distinct vertices is connected by a unique edge.

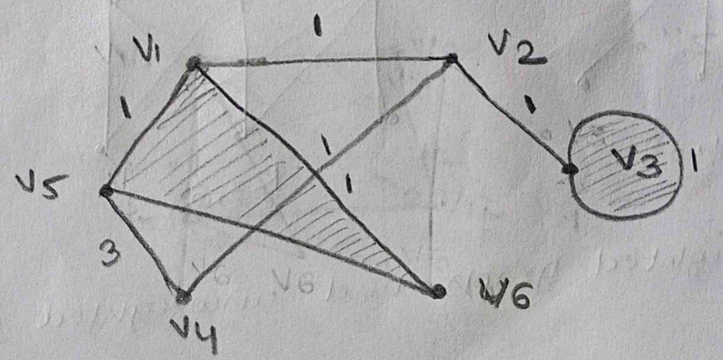
3. Draw the graph whose adjacency matrix is shown below?

$$\begin{array}{c|cccccc} & v_1 & v_2 & v_3 & v_4 & v_5 & v_6 \\ \hline v_1 & 0 & 1 & 0 & 0 & 1 & 1 \\ v_2 & 1 & 0 & 1 & 1 & 0 & 0 \\ v_3 & 0 & 1 & 1 & 0 & 0 & 0 \\ v_4 & 0 & 1 & 0 & 0 & 3 & 0 \\ v_5 & 1 & 0 & 0 & 3 & 0 & 1 \\ v_6 & 1 & 0 & 0 & 0 & 1 & 0 \end{array}$$

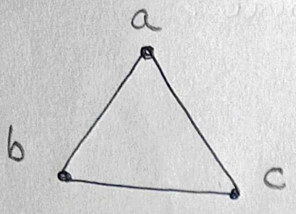
$\because$ {this is a undirected graph



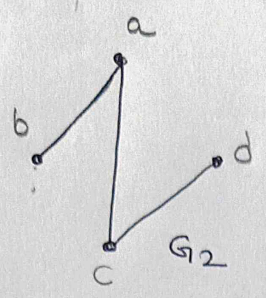

(or)



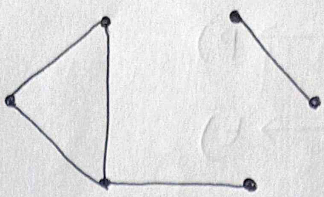
4. Find the complements of each graph show below




$G_1$



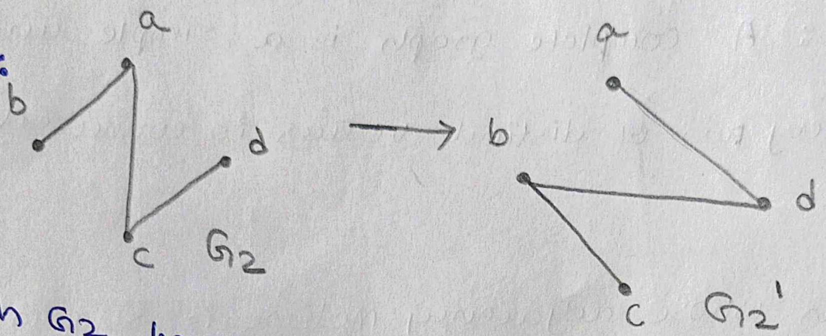

$G_2$



$G_3$

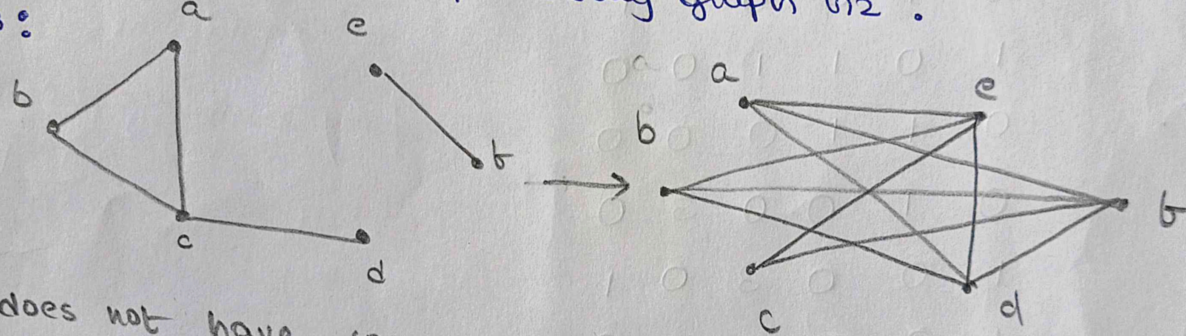
Graph $G_1$ does not have complements because it has equal no. of sides.

Graph $G_2$:



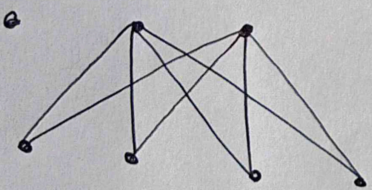

Now graph $G_2$ has a complementary graph $G_2'$ !

Graph $G_3$:

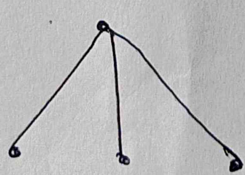



No, it does not have complementary graph.

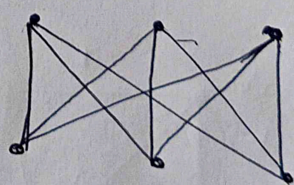
5. What distinguishes a weighted graph from an unweighted one? Define a bipartie graph and check the following graphs are complete biparlte graph or not



$K_{2,4}$

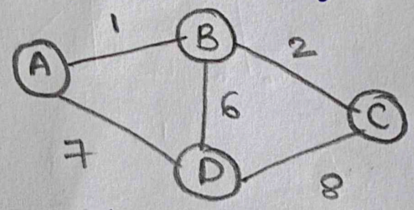
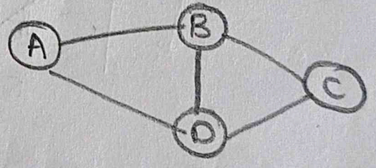


$K_{1,3}$



$K_{3,3}$

The difference between weighted graph and unweighted graph is as follows :

| Weighted Graph | Unweighted Graph. |
|---|---|
| → A weighted graph assigns a value or weight to each edge. | → Whereas, in unweighted graph there is no value assigned to a graph. |
| → In weighted graph each edge connects a pair of vertices. | → In unweighted graph all edges are equal and there's no specific value associated with moving from one vertex to another. |
| → In weighted graph the assigning values are distance or time travel, shortest path etc | → There is no assigning value for a graph. |
| → This are used in algorithms such as real-world problems like navigation system, least expensive set of purchase etc | → This are used in the presence or absence of a connection between nodes such as social network analysis, structure of the internet etc. |
| ex :  Weighted graph | ex :  Unweighted graph. |

→

Defination of Bipartite graph : A graph is bipartite if the vertices can be partioned into two sets x and Y so that every edge has one endpoint in x and the other in Y.

For a graph to be a bipartite it should satisfy some conditions :

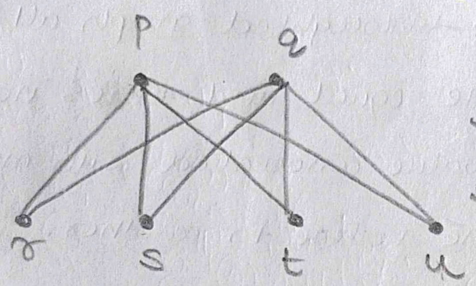
1. All the vertices of the graph should be divided into two distinct

sets of vertices X and Y

2. All the vertices present in the set X should only be connected to the vertices present in the set Y with some edges.

3. Both the sets that are created should be distinct that means both should not have same vertices in them.

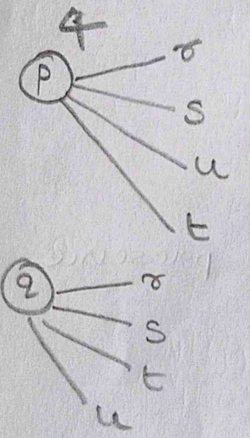
example 1:




$V = \{p, q, r, s, t, u\}$

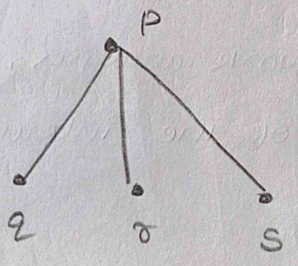
$S_1 = \{p, q\}$

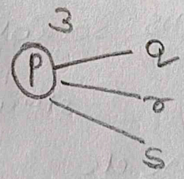
$S_2 = \{r, s, t, u\}$




Now the vertices (p, q) of sub set ($S_1$) are connected to ~~the~~ all the vertices ~~of~~ (r, s, t, u, v) of sub set ($S_2$) graph. Then this is called as complete bipartite graph.

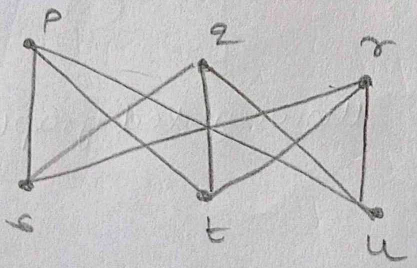
example 2:

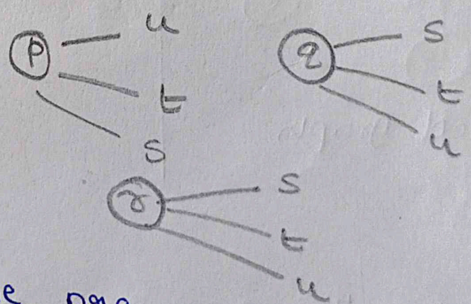



This is also a bipartite graph.

example 3:




The vertices (p, q, r) of subset one are connected to all the vertices (s, t, u) of subset two. Then this is a complete bipartite graph.

6. Let G be a graph with vertex set $V(G) = \{a, b, c, d, e, f\}$ and edge set $E(G) = \{ab, ae, bc, cc, de, ed\}$

a. Draw G

b. Is G simple?

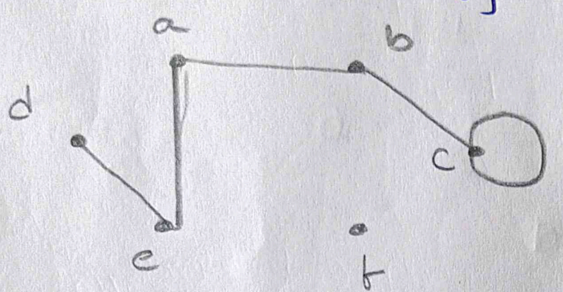
c. List the degree of every vertex

d. find all edges incident of b

e. List all neighbours of a

f. Give the adjacency matrix for G.

a. $V(G) = \{a, b, c, d, e, f\}$



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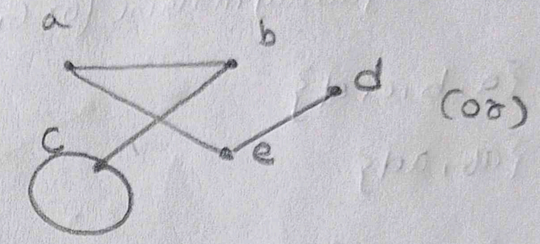

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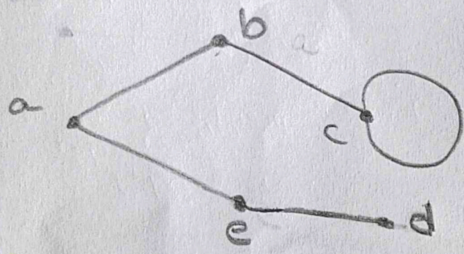
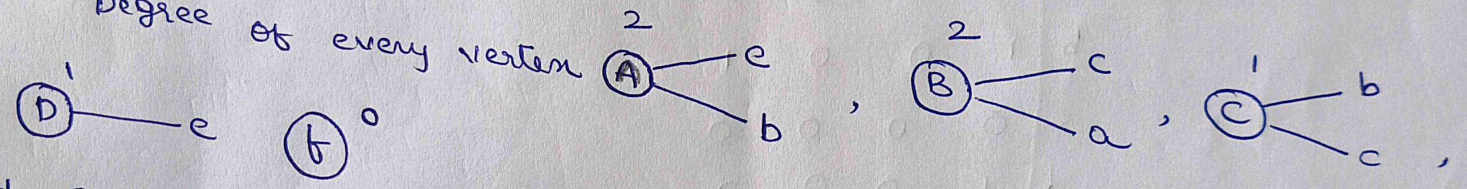


b. No, G, is not simple (because it has a loop)

c. Degree of every vertex



d. Edges incident from b are $\{ba, bc\}$

e.

f.

$$\begin{array}{c|cccccc} & a & b & c & d & e & f \\ \hline a & 0 & 1 & 0 & 0 & 1 & 0 \\ b & 1 & 0 & 1 & 0 & 0 & 0 \\ c & 0 & 1 & 1 & 0 & 0 & 0 \\ d & 0 & 0 & 0 & 0 & 1 & 0 \\ e & 1 & 0 & 0 & 1 & 0 & 0 \\ f & 0 & 0 & 0 & 0 & 0 & 0 \end{array}$$

Adjacency matrix of given G.

7. Let G be a graph with vertex set $V(G) = \{a, b, c, d\}$ and edge set $E(G) = \{ab, ad\}$

a. Draw G

b. Is G simple?

c. List the degree of every vertex

d. Give the adjacency matrix for G.

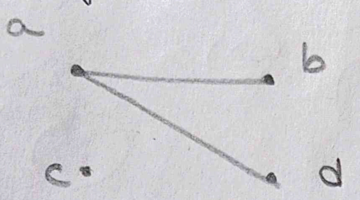
$V = 4$

$E = \frac{n(n-1)}{2} = \frac{4(4-1)}{2}$

$|E| = 3$

a. $V(G) = \{a, b, c, d\}$

$E(G) = \{ab, ad\}$




$6C_2 = 6\times5 = 30$

b. Yes, it is a simple graph

c. A — b, d (2)   B — a (1)   D — a (1)   c

d. Adjacency matrix

| | a | b | c | d |
|---|---|---|---|---|
| a | 0 | 1 | 0 | 1 |
| b | 1 | 0 | 0 | 1 |
| c | 0 | 0 | 0 | 0 |
| d | 1 | 0 | 0 | 0 |

8. Let G be a graph with the vertex set $V(G) = \{a, b, c, d, e, f\}$ edge set $E(G) = \{ad, ae, bd, cd, ce, cf\}$

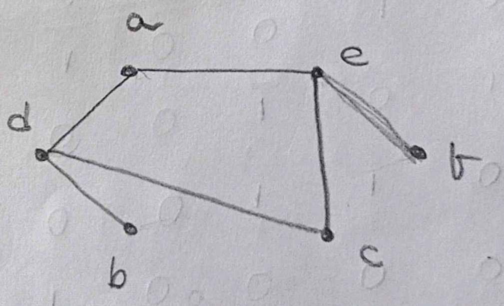
a. Draw G

b. Is G simple ?

c. Is G bipartite

d. List the degree of every vertex

e. Give the adjacency matrix for G.



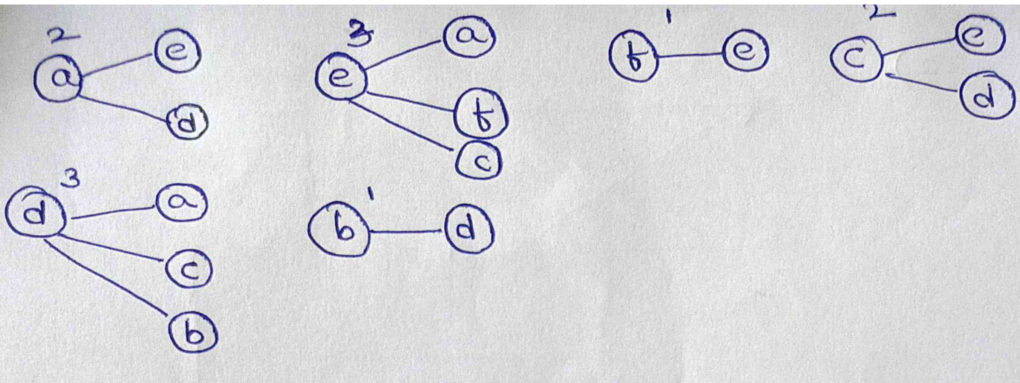

a. $V(G) = \{a, b, c, d, e, f\}$

$E(G) = \{ad, ae, bd, cd, ce, cf\}$

b. It is a simple graph

c. It is not a bipartite graph.

d.



e. Adjacency matrix

| | a | b | c | d | e | f |
|---|---|---|---|---|---|---|
| a | 0 | 0 | 0 | 1 | 1 | 0 |
| b | 0 | 0 | 0 | 1 | 0 | 0 |
| c | 0 | 0 | 0 | 1 | 0 | 0 |
| d | 1 | 1 | 1 | 0 | 0 | 0 |
| e | 1 | 0 | 1 | 0 | 0 | 1 |
| f | 0 | 0 | 0 | 0 | 1 | 0 |

9. Draw the graph for each of the following of adjacency matrices given below :

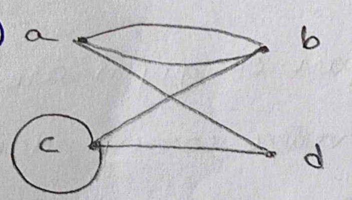
a.

| | a | b | c | d |
|---|---|---|---|---|
| a | 0 | 2 | 0 | 1 |
| b | 2 | 0 | 1 | 0 |
| c | 0 | 1 | 1 | 1 |
| d | 1 | 0 | 1 | 0 |

b.

| | a | b | c | d |
|---|---|---|---|---|
| a | 0 | 1 | 2 | 1 |
| b | 1 | 2 | 1 | 0 |
| c | 2 | 1 | 0 | 0 |
| d | 1 | 0 | 0 | 0 |

1)

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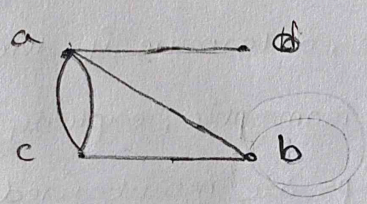



10. Draw the diagraph for each of the adjacency matrices given below :

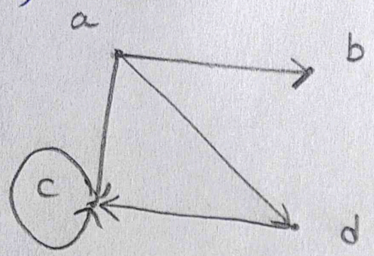
a.

| | a | b | c | d |
|---|---|---|---|---|
| a | 0 | 1 | 1 | 1 |
| b | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 1 | 0 |
| d | 0 | 0 | 1 | 0 |

b.

| | a | b | c | d |
|---|---|---|---|---|
| a | 0 | 1 | 0 | 0 |
| b | 0 | 0 | 1 | 0 |
| c | 0 | 0 | 0 | 1 |
| d | 1 | 0 | 0 | 0 |

1)

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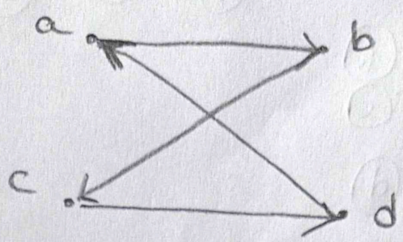
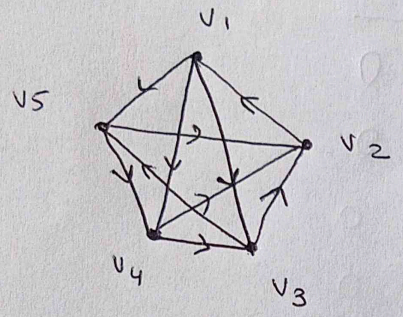
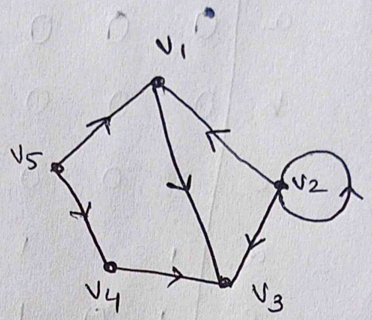



11. Find the adjacency matrix for each digraphs or tournaments given below.

a)




b)



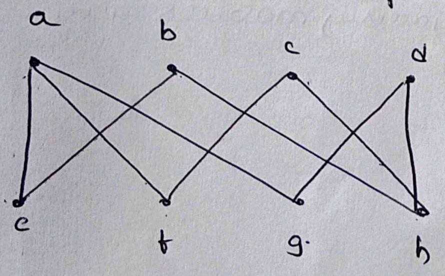

1)

| | V1 | V2 | V3 | V4 | V5 |
|---|---|---|---|---|---|
| V1 | 0 | 0 | 1 | 1 | 1 |
| V2 | 1 | 0 | 0 | 0 | 0 |
| V3 | 0 | 1 | 0 | 0 | 1 |
| V4 | 0 | 1 | 1 | 0 | 0 |
| V5 | 0 | 1 | 0 | 1 | 0 |

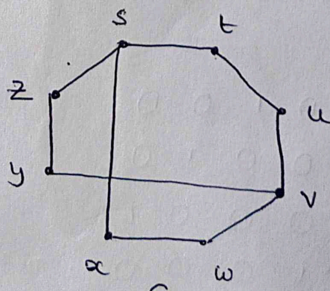
2)

| | V1 | V2 | V3 | V4 | V |
|---|---|---|---|---|---|
| V1 | 0 | 0 | 1 | 0 | 0 |
| V2 | 1 | 1 | 1 | 0 | 0 |
| V3 | 0 | 0 | 0 | 0 | 0 |
| V4 | 0 | 0 | 1 | 0 | 0 |
| V5 | 1 | 0 | 0 | 1 | 0 |

12. For each promblems below, determine if the given pair of graphs are isomorphic. For those that are isomorphic, explicity give the vertex correspondance and check that edge relationships are maintained. Otherwise, provide reasoning for why the pair of graphs are not isomorphic




$G_1$




$G_2$

To say the Graph G1 and G2 are isomophoic

The two graphs have same vertex and edges.

i.e the given graph G1 and another graph G2 has same vertices (8) and same edges (10).

To say both the graphs are isomorphic

1. Same vertices = 8

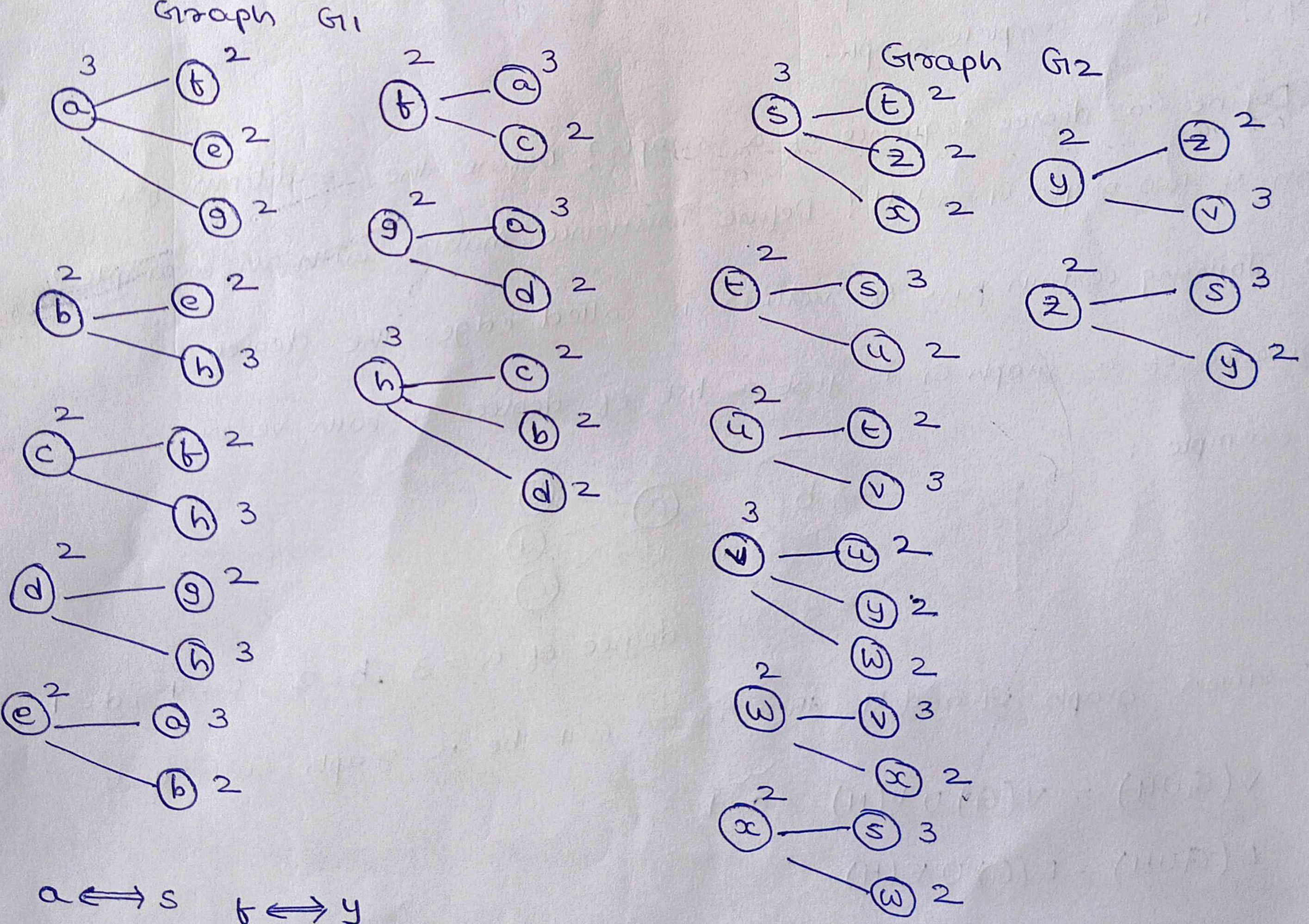
2. Same edges = 10

3. Degree sequence :

$$(a,b,c,d,e,f,g,h) = \begin{array}{cccccccc} a & b & c & d & e & f & g & h \\ (3, & 2, & 2, & 2, & 2, & 2, & 2, & 3) \end{array}$$

$$(s,t,u,v,w,x,y,z) = \begin{array}{cccccccc} s & t & u & v & w & x & y & z \\ (3, & 2, & 2, & 3, & 2, & 2, & 2, & 2) \end{array}$$

4. one-to-one mapping




$a \Longleftrightarrow s$ $\quad f \Longleftrightarrow y$

$b \Longleftrightarrow t$ $\quad g \Longleftrightarrow z$

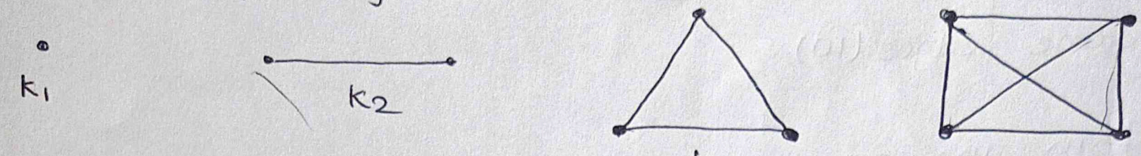
$c \Longleftrightarrow u$ $\quad h \Longleftrightarrow v$

$d \Longleftrightarrow w$

$e \Longleftrightarrow x$

Hence, graph G1 and graph G2 are isomorphic.

13. List the properties of complete graph and identify the complete graphs from the following :




A complete graph is a graph is a graph in which every vertex is connected to every other vertex.

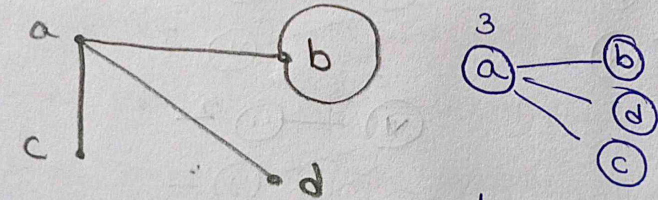
A complete graph is an undirected graph where every pair of distinct vertices is connected by a unique edge.

1. Not a complete graph
2. Yes, it is a complete graph
3. Yes, it is a complete graph
4. Yes, it is a complete graph.

14. Define a degree sequence of a graph? Define the conditions for union of two graphs G and H? Define incidence matrix with an example?

→ Joining certain pair of vertices is called edge. The degree sequence of a graph G is just a list of degrees of each vertex.

For example :



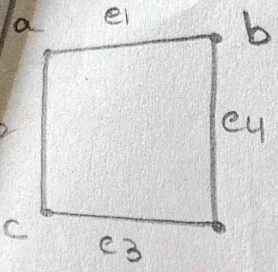

degree of a = 3 , b = 2 , c = 1 , d = 1

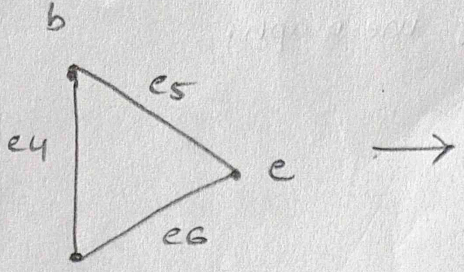
→ Given graph G and H their union will be a graph such that

$V(G \cup H) = V(G) \cup V(H)$ and

$E(G \cup H) = E(G) \cup E(H)$

The union of G and H is denoted as $G \cup H$




Graph 'G' d Graph 'H'

$V(G) = \{a, b, c, d\}$

$V(H) = \{b, d, e\}$

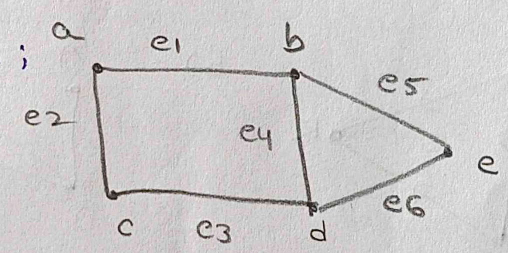
$V(G \cup H) = \{a, b, c, d, e\}$

$E(G) = \{e_1, e_2, e_3, e_4\}$

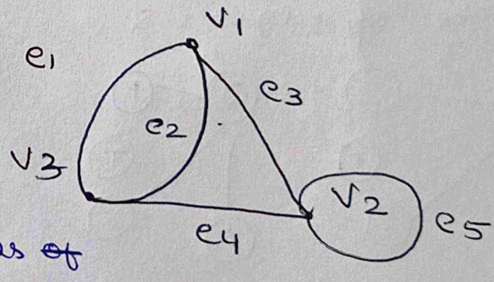
$E(H) = \{e_4, e_5, e_6\}$

$E(G \cup H) = \{e_1, e_2, e_3, e_4, e_5, e_6\}$

Now the union graph $G \cup H$;




15. Why matrix representations of graphs are useful for computer programs. Also write the adjacency matrix for following gram



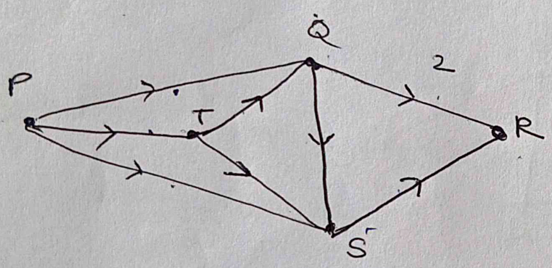

Mainly computers are often linked together into a network such ~~that~~ as a local area network. A network can also be represented mathematically as a graph. By adding properties ~~of~~ to the nodes and edges to represent the capacities of the network. ~~We~~ As for how graph theory works, at the present time is not fully aligned with computer. We have methods of drawing graph networks so that the human eye can judge the properties for themselves. We have ways to describe the structures inside graphs. We have algorithms about how to compare the data in the graph and see the relationships b/w diff parts of the graph.

| | $v_1$ | $v_2$ | $v_3$ |
|---|---|---|---|
| $e_1$ | | | |
| $e_2$ | | | |
| $e_3$ | | | |
| $e_4$ | | | |
| $e_5$ | | | |

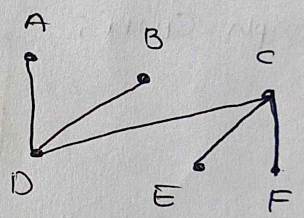
## PART-B.

1. Write down the number of vertices, number of edges, and the degree of each vertex

a)



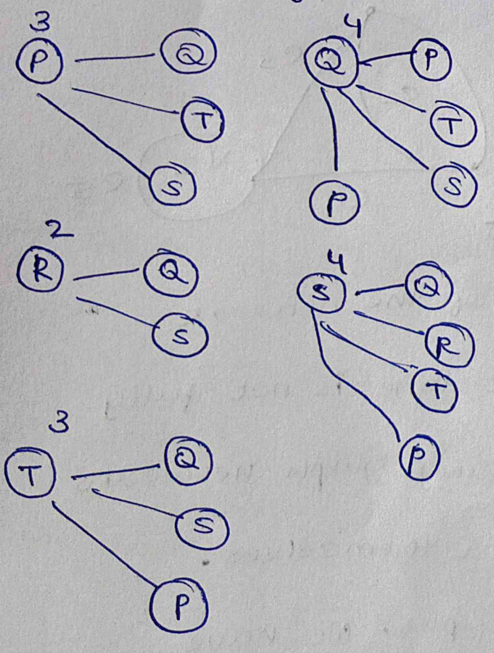

b)

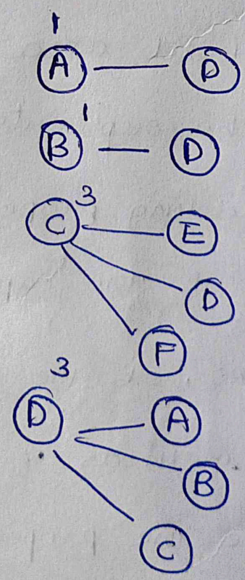



a) number of vertices : 5

{P, Q, R, S, T}

number of edges : 8



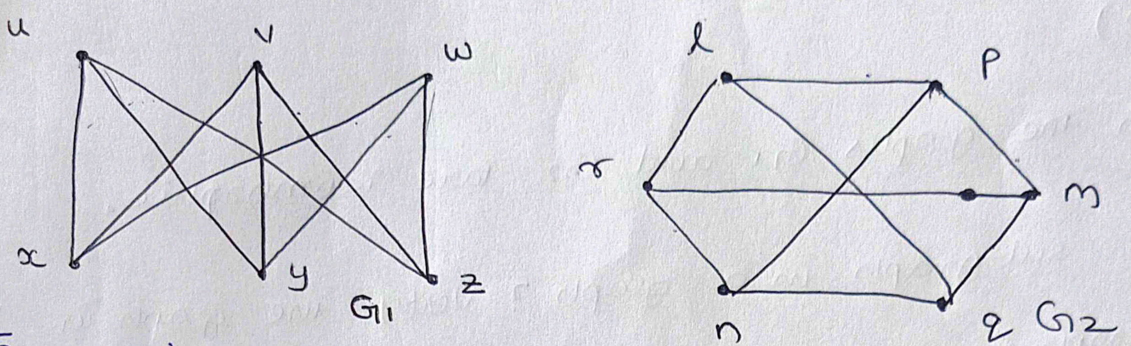




degree of each vertex :

{P, Q R, S, T} = {3, 4, 2, 4, 3}

{A, B, C, D} = {1, 1, 3, 3}

~~Draw~~ Define isomerism of graphs? State that the two labelled graphs are isomorphic or not with reasons.




Isomorphic graphs are those which have same no. of vertices, same no. of edges, an equal number vertices with even degree and vertex correspondance & edge correspondance valid.

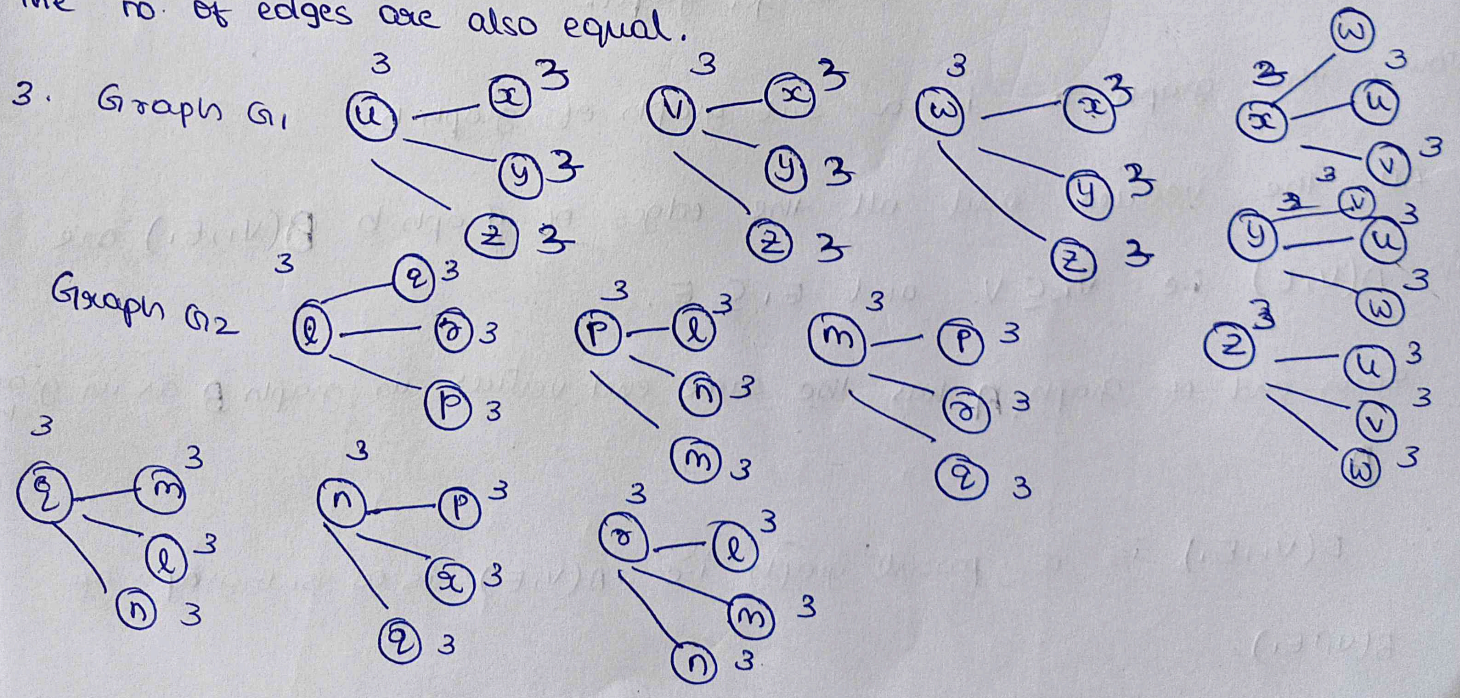
The above G1 and G2 we can say that:

1. The Graph G1 has 6 vertices {u, v, w, x, y, z} and Graph G2 has also 6 vertices {l, p, m, q, n, r}. The both graphs have same no. of vertices {6}.

2. The Graph G1 has 9 edges and graph G2 has 9 edges. The no. of edges are also equal.

3. Graph G1

Graph G2



Both the graphs G1 and G2 the vertices have same no. of degree

4. $(u \longleftrightarrow l)$ $(y \longleftrightarrow n)$

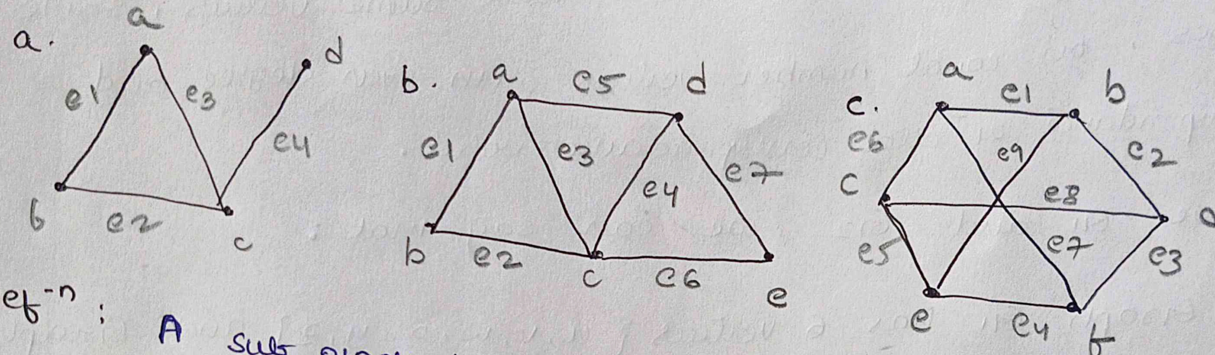
$(v \longleftrightarrow p)$ $(z \longleftrightarrow r)$

$(w \longleftrightarrow m)$

$(x \longleftrightarrow q)$

$\therefore$ The Both the graphs $G_1$ and $G_2$ are isomorphic.

3. Define a subgraph in a graph? verify the graph in
a. is a subgraph of the graph in (b), but is not a subgraph of the graph c.




Def-n: A sub graph H of a graph G is said to be a proper subgraph of G if either V(H) is a proper subset of V(G) or E(H) is a proper subset of E(G). (or) a graph all of whose points and lines are connected in a larger graph.

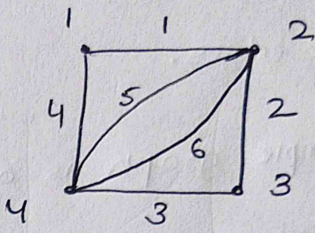
Now, the graph a is a sub graph of graph b.

- All the vertices and all the edges of graph b $B(V_1, E_1)$ are in $A(V, E)$ i.e $V_1 \subseteq V$ and $E_1 \subseteq E$.
- Each end of graph A has the same end vertices in graph B as in graph A.

$\therefore$ $B(V_1, E_1)$ is a parent graph i.e. $A(V, E)$ is a subgraph of $B(V_1, E_1)$.

The graph a is not a sub graph c because the vertices and edges of graph c are different from graph. Hence graph a is a sub graph of graph b but not graph c.

4. Explain the following : a. Adjaceny matrix b. Incidence matrix
Write the adjaceny & incidence matrix for the following graph :




a. The adjaceny matrix, also called as connection matrix, is a matrix containing rows and columns which is used to represent a simple labelled graph with 0 or 1 in the position of (vi, vj)

b. The order of an incidence matrix of n number of nodes & b number of branches n×b. For each and every graph, incidence matrix can be obtained

Adjaceny matrix :

$$\begin{array}{c|c} & \begin{matrix} 1 & 2 & 3 & 4 \end{matrix} \\ \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \end{matrix} & \begin{bmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 2 \\ 0 & 1 & 0 & 1 \\ 1 & 2 & 1 & 0 \end{bmatrix} \end{array}$$

(doubt)

Incidence Matrix :

$$\begin{array}{c|c} & \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 \end{matrix} \\ \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \end{matrix} & \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 \end{bmatrix} \end{array}$$

5. Explain and draw the following graphs:

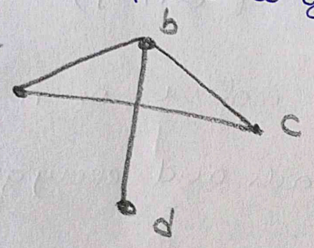
(i) a simple graph

(ii) a non-simple graph with no loops.

(iii) a non-simple graph with no multiple edges.

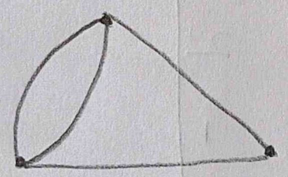
(iv) a non-simple graph with no multiple edges, each with five vertices and eight edges.

1. A simple graph is a graph that does not have more than one edge b/w two vertices and no edge starts and ends at the same vertex. In simple words, a simple graph is a graph without loops and multiple edges.



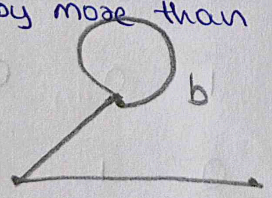

simple graph

2. A non-simple graph with no loops means a type of graph that have multiple edges which connect same two vertices but there are still no loops.



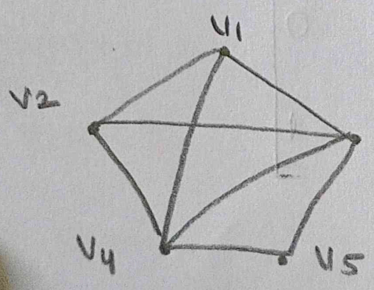
Non-simple graph (no loops)

3. A non-simple graph has loops so, where the edge can be connected to a vertex to itself creating a loop where there are no pair of vertices connected by more than one edge.




Non-simple graph (no multiple edges)

4.




5 vertices (8 edges)

Ex Show that the two graphs in fig a are isomorphic by suitably labelling the vertices, and also explain why the two graphs in fig (b) are not isomorphic.

(X)

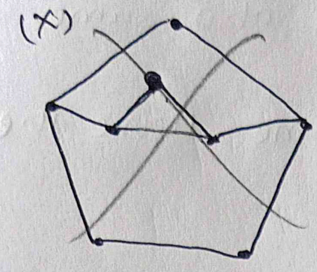


Fig a :

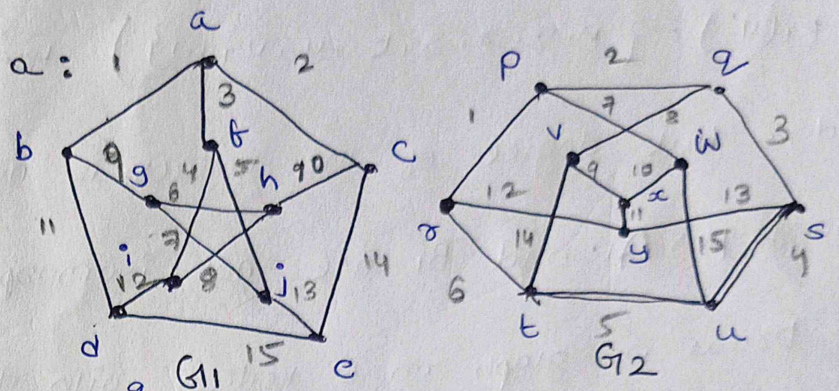
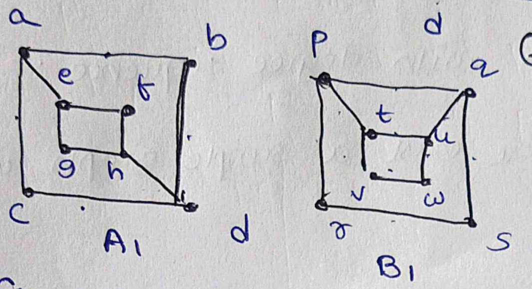



Fig b :




1. Graph G1 and graph G2 in fig a isomorphic because:

a. The graph G1 has 10 vertices {a, b, c, d, e, f, g, h, i, j} and even graph G2 has 10 vertices {p, q, r, s, t, u, v, w, x, y}

b. The graph G1 has 15 edges and graph G2 has also 15 edges.

c.

1. a 3 — b 3, f 3, c 3
   b 3 — a 3, g 3, d 3
   c 3 — a 3, h 3, e 3
   d 3 — b 3, i 3, e 3
   e 3 — c 3, j 3, d 3
   f 3 — a 3, i 3, j 3
   g 3 — b 3, h 3, j 3
   h 3 — c 3, g 3, i 3
   i 3 — d 3, f 3, h 3
   j 3 — g 3, f 3, e 3

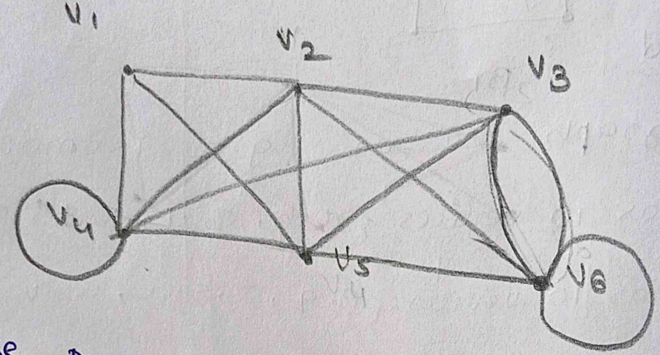
2. p 3 — q 3, w 3, r 3
   q 3 — p 3, v 3, s 3
   r 3 — p 3, y 3, t 3
   t 3 — v 3, r 3, u 3
   u 3 — t 3, w 3, s 3
   s 3 — q 3, y 3, u 3
   v 3 — q 3, x 3, t 3
   w 3 — p 3, x 3, u 3
   x 3 — v 3, w 3, y 3

Every vertex has even degree

∴ Both Graphs G1 and graph G2 are isomorphic

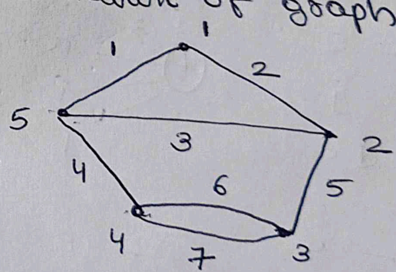
2. Graph $A_1$ and $B_1$ are not isomorphic because they have same vertices $(A_1(V_1) = \{a, b, c, d, e, f, g, h\})$, $(B_1(V_2') = \{p, q, r, s, t, u, v, w\})$ ~~the~~ and also same edges but degree of the vertices is not same. Hence the two graphs $A_1$ and $B_1$ are not isomorphic.

7. Draw a graph on 6 vertices with degree sequence $\overset{v_1}{3}, \overset{v_2}{3}, \overset{v_3}{5}, \overset{v_4}{5}, \overset{v_5}{5}, \overset{v_6}{5}$ & verify does there exist a simple graph with these degrees?




Hence by these graph we can say that this is not a
2 simple graph there. exists multiple loops and multiple edges.

8. (i) Write down the adjacency and incidence matrix of graph
6 in Fig(a)




3 (ii) Draw the graph whose adjacency matrix is given in fig (b)

$$\begin{array}{c|ccccc} & 1 & 2 & 3 & 4 & 5 \\ \hline 1 & 0 & 1 & 1 & 2 & 0 \\ 2 & 1 & 0 & 0 & 0 & 1 \\ 3 & 1 & 0 & 0 & 1 & 1 \\ 4 & 2 & 0 & 1 & 0 & 0 \\ 5 & 0 & 1 & 1 & 0 & 0 \end{array}$$

(iii) Draw the graph whose incidence matrix is given in Fig(c)

| | a | b | c | d | e | f | g | h |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 4 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 5 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |

(i) adjacency matrix

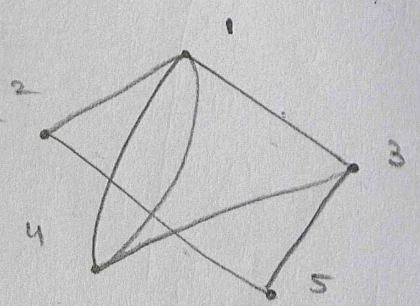
| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 | 1 |
| 2 | 1 | 0 | 1 | 0 | 1 |
| 3 | 0 | 1 | 0 | 2 | 0 |
| 4 | 0 | 0 | 2 | 0 | 1 |
| 5 | 1 | 1 | 0 | 1 | 0 |

| | $v_1$ | $v_2$ | $v_3$ | $v_4$ | $v_5$ |
|---|---|---|---|---|---|
| $v_1$ | 0 | 1 | 0 | 0 | 1 |
| $v_2$ | 1 | 0 | 1 | 0 | 1 |
| $v_3$ | 0 | 1 | 0 | 2 | 0 |
| $v_4$ | 0 | 0 | 2 | 0 | 1 |
| $v_5$ | 1 | 1 | 0 | 1 | 0 |

(ii) incidence matrix :

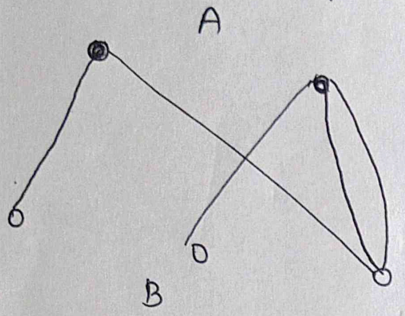
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 4 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| 5 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |

(ii)

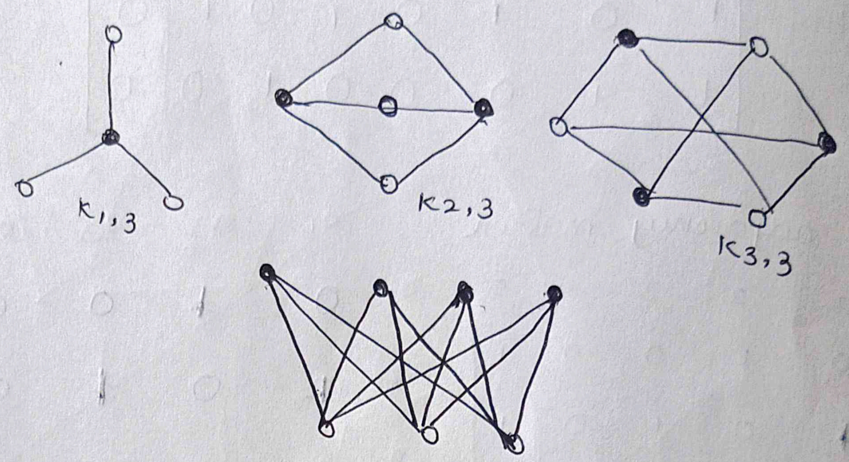



(iii)

9. Define bipartite graphs and complete bipartite graphs. Justify the graph in fig(a) is a bipartite graph or not & also the graphs in fig (b) are complete bipartite graphs or not.




(a)




(b)

10. Draw a digraph for the following:

(a) Snakes eat frogs & birds eat spiders, birds and spiders both eat insects, frogs eat snails, spiders and insects. Draw a digraph representating this predatory behaviour.

(b) John likes Joan, Jean and Jane; Joe likes Jane and Joan; Jean and Joan like each other. Draw a digraph illustrating these relationships b/w John. Joan, Jean, Jane, and Joe.