

Date → 16/10/2022

Q) Can there exist any graph without any vertices.

* Ans → No.

- * 1. vertex → Initial & terminal vertex
- 2. Edge
- 3. Self loop
- 4. Parallel edge (Starting and ending vertex are same)
- 5. Incidence Property denotes if two vertices are connected or not. Or some common vertex and connect them by there or not.
- 6. Adjacency Property
- 7. Pendant vertex → vertex connected with only 1 edge.
- 8. Degree of vertex is the no. of edges connected with it.

* Handwriting

$$\sum_{i=1}^n \delta(v_i) = 2e$$

→ The no. of vertices with odd degree in a graph is always even.

$$\sum \delta(v_i) = 2e$$

$$\sum_{\text{odd}} \delta(v_i) + \sum_{\text{even}} \delta(v_i) = 2e$$

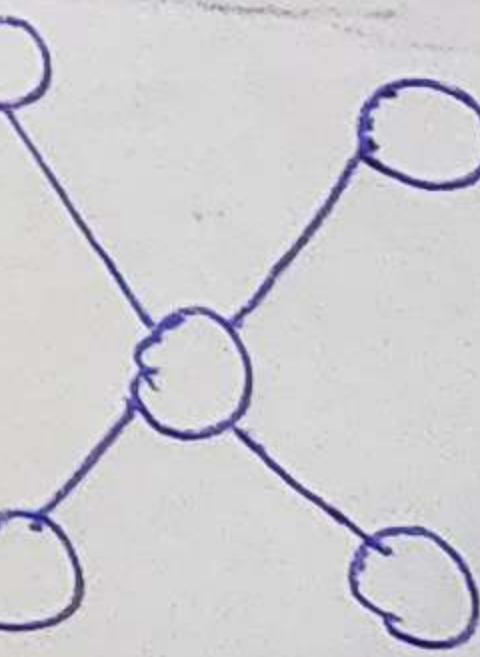
* Finite & Infinite graph

- with finite no. of edges & infinite no. of v.
 (isolated vertices)
- with infinite no. of vertices & finite no. of e.
- (Q) Show that an infinite graph with a finite no. of edges must have an infinite no. of isolated vertices.
- (Q) Show that an infinite graph with finite no. of vertices must have one pair of vertices which be join by infinite no. of parallel vertices.

* Simple graph , Multigraph , Complete graph ,
 (don't have self loop or p.e.) (only p. edge & no self loop)
 Regular graph , (Only p. edge & no self loop)
 (Degree of every v is same)

- (Q) Explain that every complete graph is regular but not all regular graph is complete.

- * Wheel graph , N-cube graph
 (center v connected) (Every v has 1 bid fibb.)



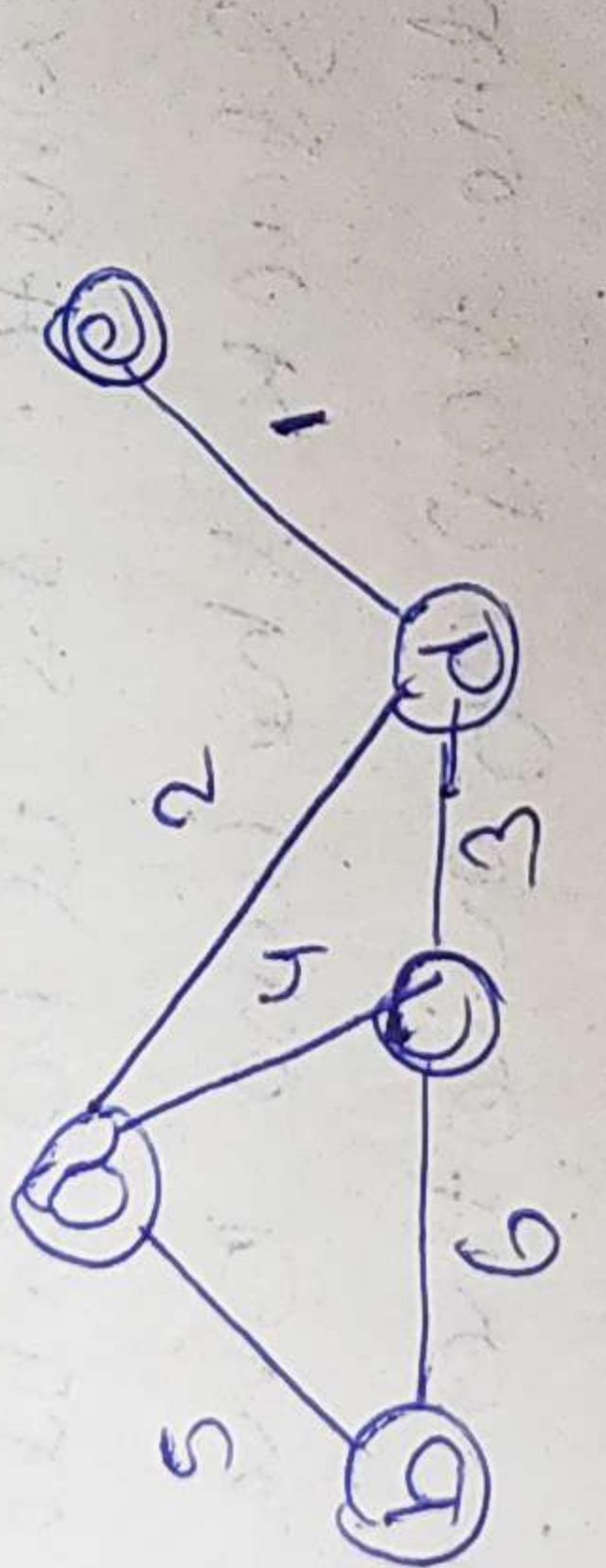
Application

* Königsberg Bridge Problem (1736) (L. Euler)

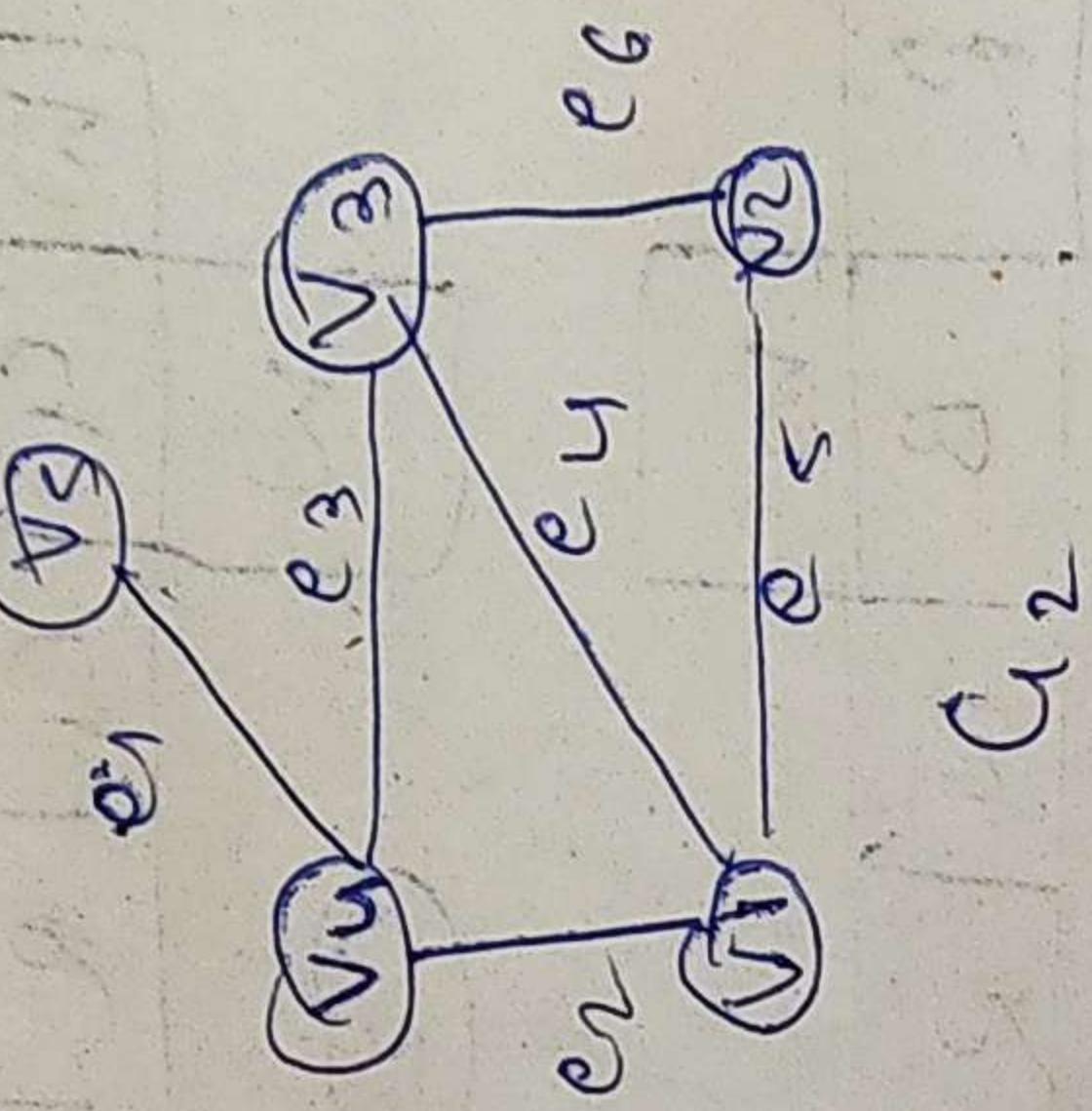
Q) Show that the minimum no. of edges with n vertices is $\frac{n(n-1)}{2}$.

* Isomorphism

Date → 18/01/23



G₁



G₂

1) $V_1 = \{a, b, c, d, e\}$

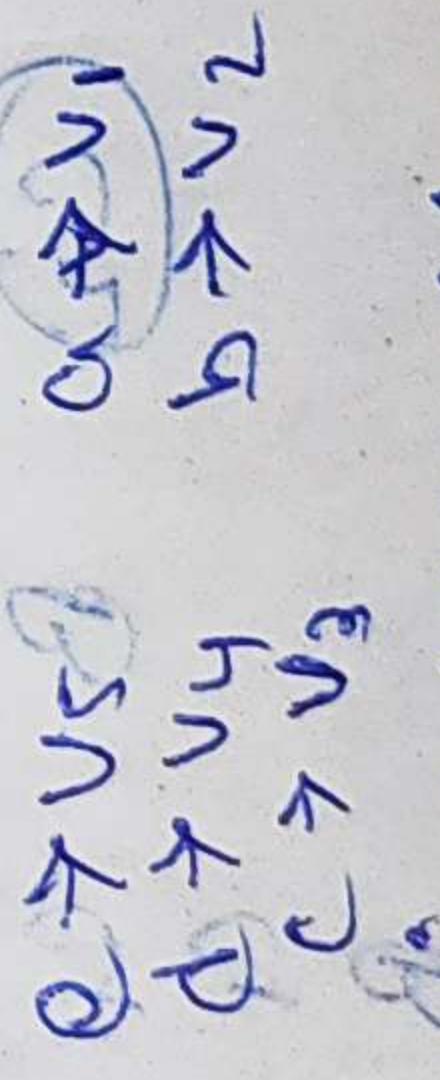
2) $E_1 = \{1, 2, 3, 4, 5, 6\}$

3) $d(1) = 3$

$d(2) = 2$

$d(3) = 3$

4) vertex correspondence



$V_2 = \{v_1, v_2, v_3, v_4, v_5, v_6\}$

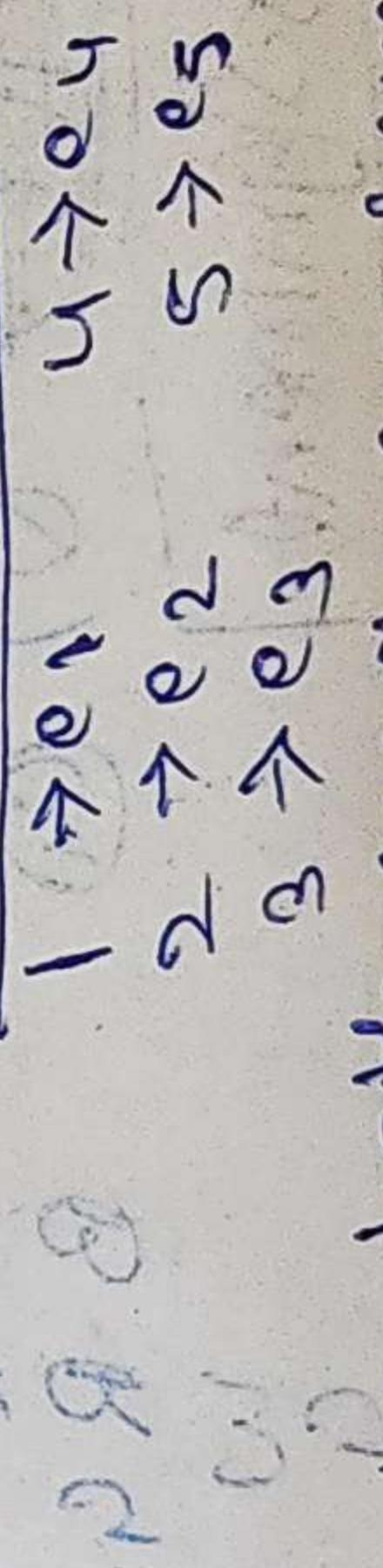
$E_2 = \{e_1, e_2, e_3, e_4, e_5, e_6\}$

$d(v_1) = 1$

$d(v_2) = 2$

$d(v_3) = 3$

Edge correspondence



Properties of isomorphism. If vertices in both graphs are same.

1) Edges are same.

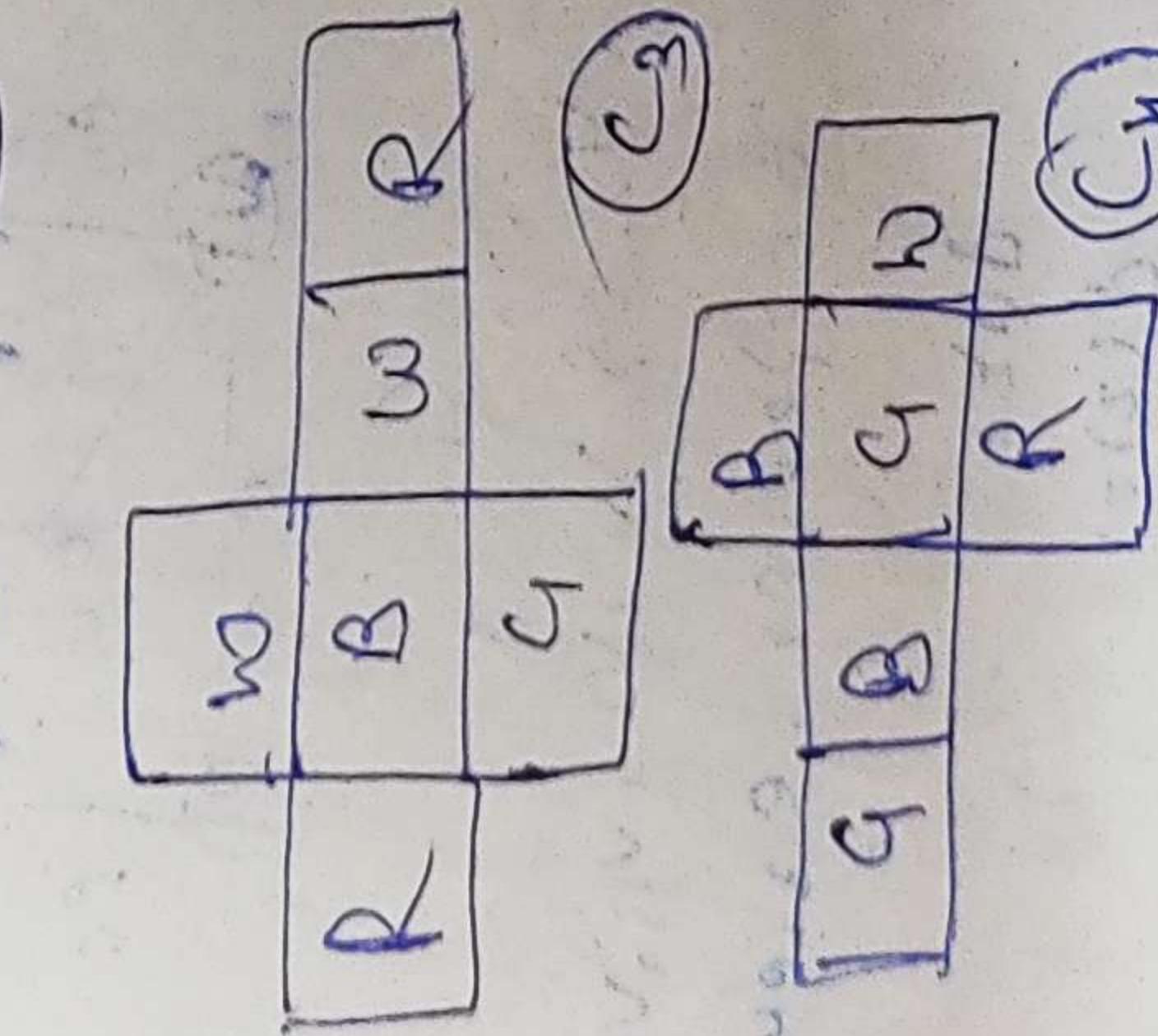
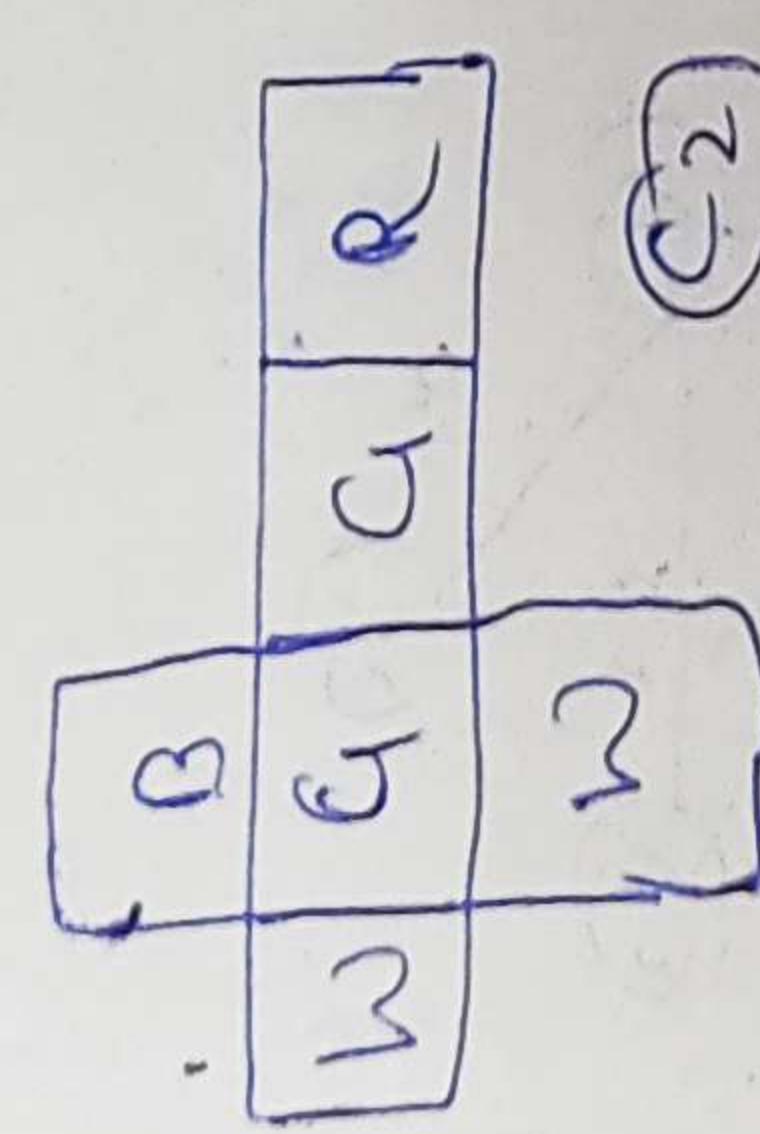
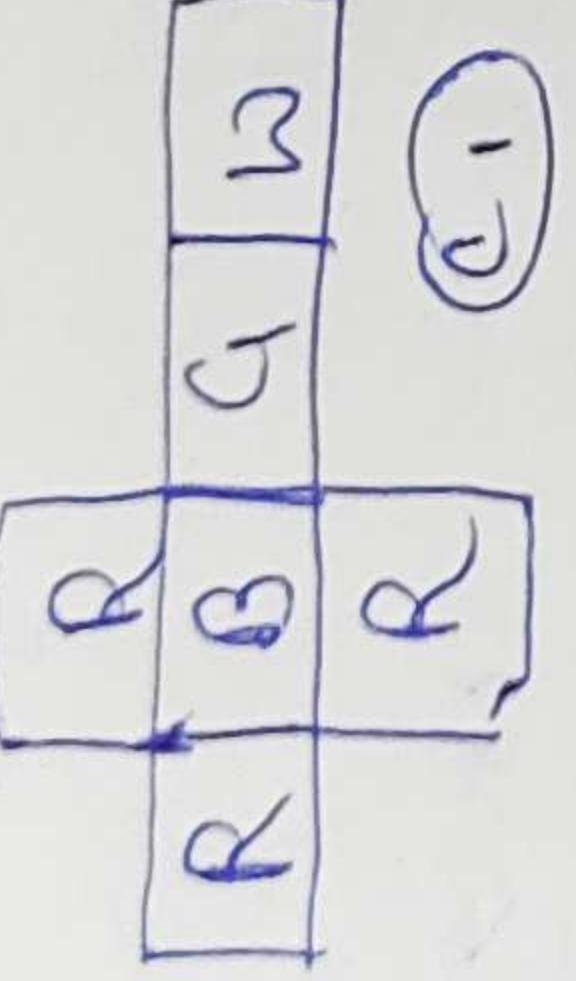
2) Both graphs have same no. of vertices with a given degree.

- 3) Both graphs have same no. of vertices with a given degree.
- 4) There must be some 1-to-1 correspondence b/w

v & e

* Subgraph → edge-disjoint
→ vertex disjoint

* multicolor cube problem



- Q) Cover 4 cubes with 6x6 faces of every cube one sequentially colored with Blue, Green+Red & white. Is it possible to stack the cube one on the top of another so that no color appears twice on any of the bottom side of the column

~~Setive~~ 0) ~~1~~ Assignment

Q) ~~1~~ ~~2~~ ~~3~~ ~~4~~ ~~5~~ ~~6~~ ~~7~~ ~~8~~ ~~9~~ ~~10~~ ~~11~~ ~~12~~ ~~13~~ ~~14~~ ~~15~~ ~~16~~ ~~17~~ ~~18~~ ~~19~~ ~~20~~ ~~21~~ ~~22~~ ~~23~~ ~~24~~ ~~25~~ ~~26~~ ~~27~~ ~~28~~ ~~29~~ ~~30~~ ~~31~~ ~~32~~ ~~33~~ ~~34~~ ~~35~~ ~~36~~ ~~37~~ ~~38~~ ~~39~~ ~~40~~ ~~41~~ ~~42~~ ~~43~~ ~~44~~ ~~45~~ ~~46~~ ~~47~~ ~~48~~ ~~49~~ ~~50~~ ~~51~~ ~~52~~ ~~53~~ ~~54~~ ~~55~~ ~~56~~ ~~57~~ ~~58~~ ~~59~~ ~~60~~ ~~61~~ ~~62~~ ~~63~~ ~~64~~ ~~65~~ ~~66~~ ~~67~~ ~~68~~ ~~69~~ ~~70~~ ~~71~~ ~~72~~ ~~73~~ ~~74~~ ~~75~~ ~~76~~ ~~77~~ ~~78~~ ~~79~~ ~~80~~ ~~81~~ ~~82~~ ~~83~~ ~~84~~ ~~85~~ ~~86~~ ~~87~~ ~~88~~ ~~89~~ ~~90~~ ~~91~~ ~~92~~ ~~93~~ ~~94~~ ~~95~~ ~~96~~ ~~97~~ ~~98~~ ~~99~~ ~~100~~ ~~101~~ ~~102~~ ~~103~~ ~~104~~ ~~105~~ ~~106~~ ~~107~~ ~~108~~ ~~109~~ ~~110~~ ~~111~~ ~~112~~ ~~113~~ ~~114~~ ~~115~~ ~~116~~ ~~117~~ ~~118~~ ~~119~~ ~~120~~ ~~121~~ ~~122~~ ~~123~~ ~~124~~ ~~125~~ ~~126~~ ~~127~~ ~~128~~ ~~129~~ ~~130~~ ~~131~~ ~~132~~ ~~133~~ ~~134~~ ~~135~~ ~~136~~ ~~137~~ ~~138~~ 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* Walk , Path & circuit :-

* walk \rightarrow blwite , alternating sequence of edges & vertices
wherever $\&$ edge can be repeated.

Eg) $V_1, V_2, \dots, V_n \rightarrow 1 - b - 3 - d - 2 + e - 5 - h - 4$

* Trail \rightarrow Blwite or walk where $\&$ can be repeated
but edges can't be repeated.

Eg) $T_1 \rightarrow 1 - b - 3 - d - 2 - e - 5 - h - 4$

* path \rightarrow Blwite or walk where $\&$ P
edges cannot be repeated.

Eg) $P_1 \rightarrow 1 - b - 3 - d - 2 - e - 5 - h - 4$

* Circuit \rightarrow It's a closed walk where $\&$ e can't be
repeated except the starting $\&$.

Eg) $C_1 \rightarrow 1 - b - 3 - d - 2 - a - 1$

Ans) Shows with proper example that every self-loop
is a circuit but not every circuit has self-loop.
Path between every pair of vertices otherwise
disconnected.

* Connected graph:- There exists atleast one
path between every pair of vertices otherwise
disconnected.

~~discrete~~

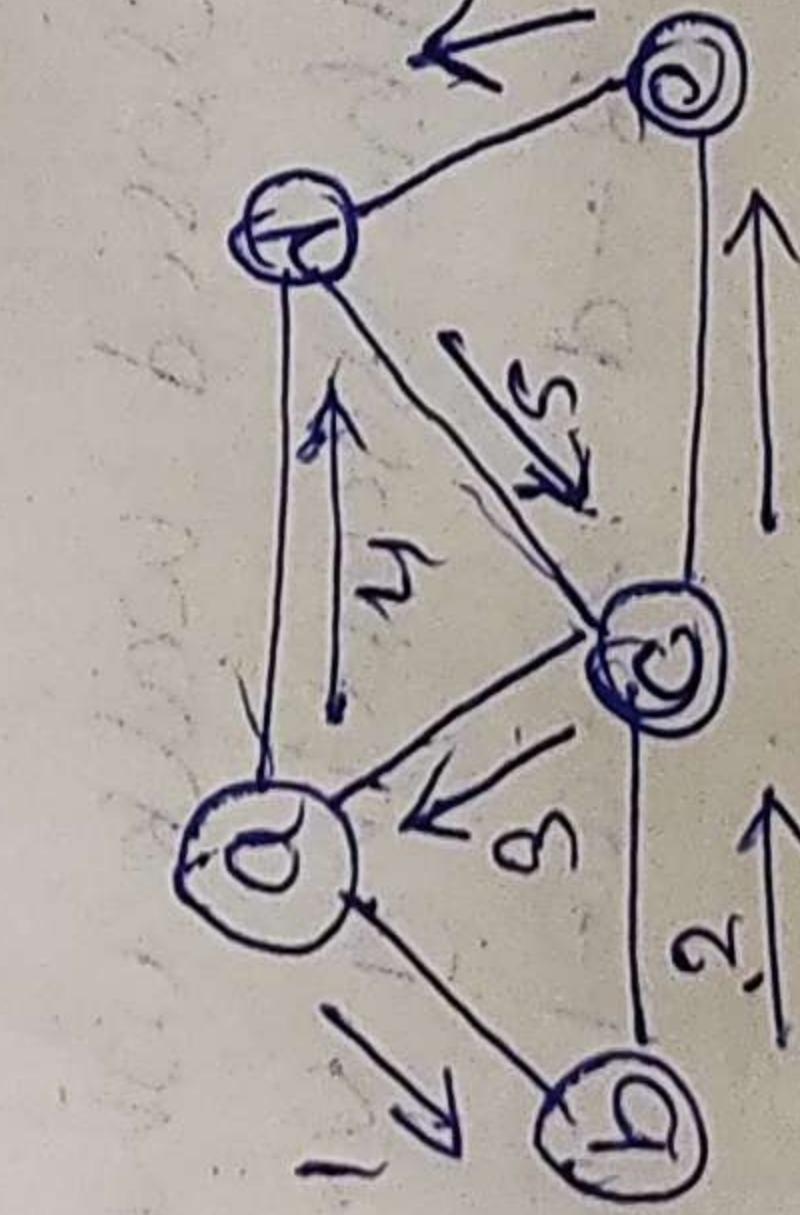
Date \rightarrow 25/01/2020

- * Component \rightarrow A subgraph within which every node is connected.
- * Is denoted by K . Connected graph $K^{1,4}$.

* Euler Graph \rightarrow A graph of even vertex degree can be drawn as Euler graph.

(Q) How will solve the Kongsgberg bridge problem.

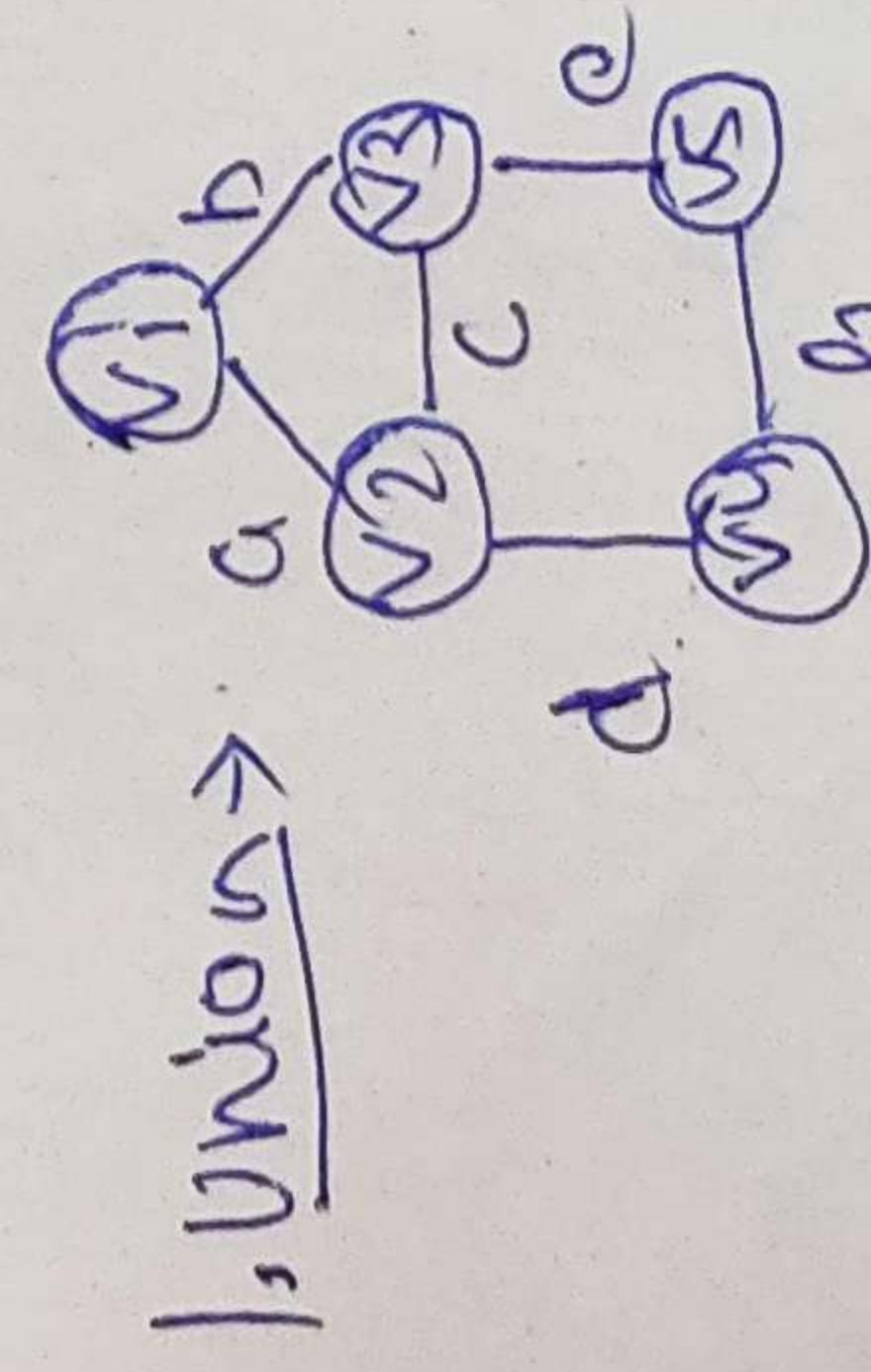
* Open Euler graph or unicursal graph \rightarrow



\rightarrow Start from a vertex & traverse every edge exactly once & reach to another vertex.

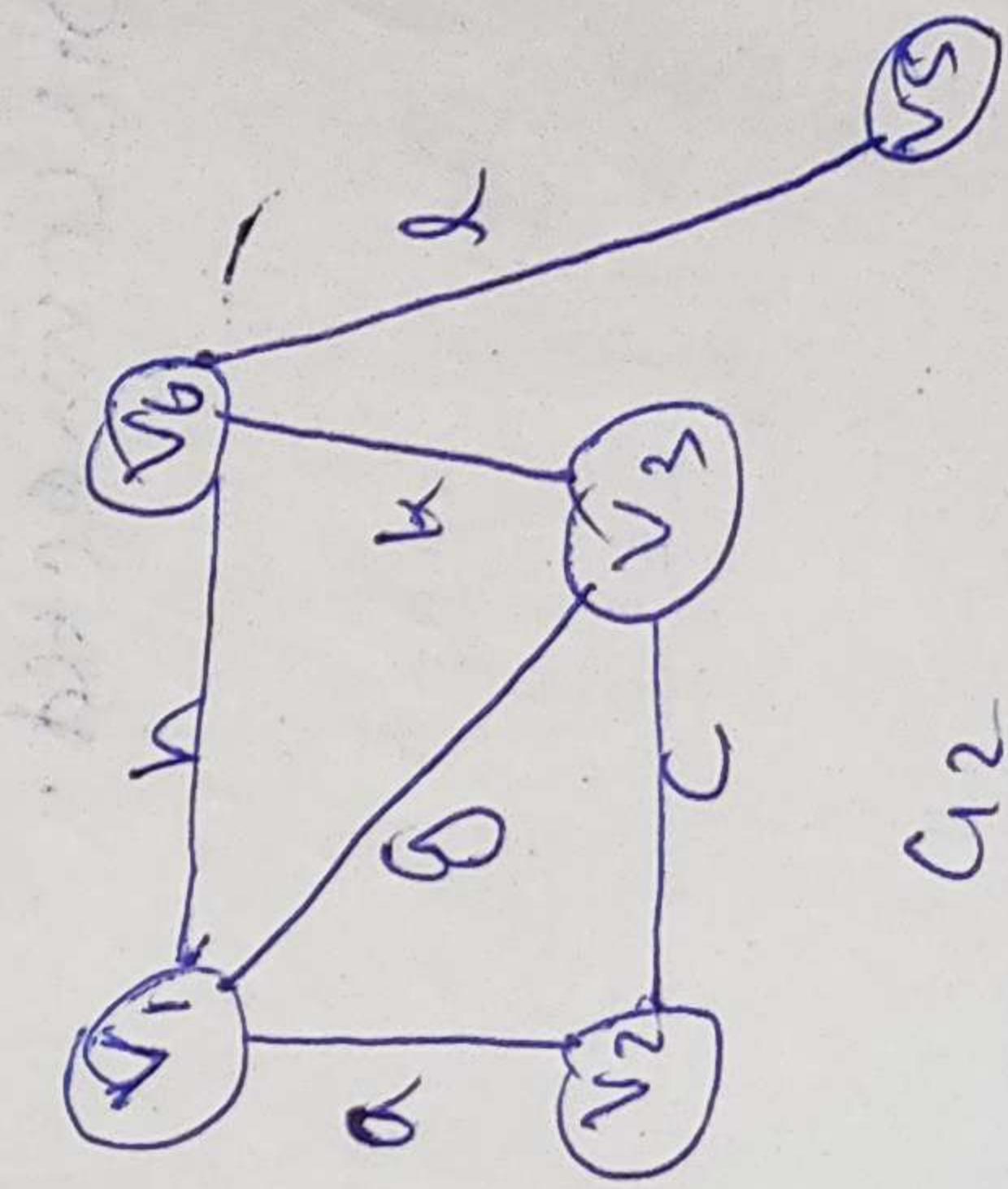
* Operation on graph :-

1. Union
2. Intersection
3. Ring sum w/ deletion
5. Fusion.



G_1

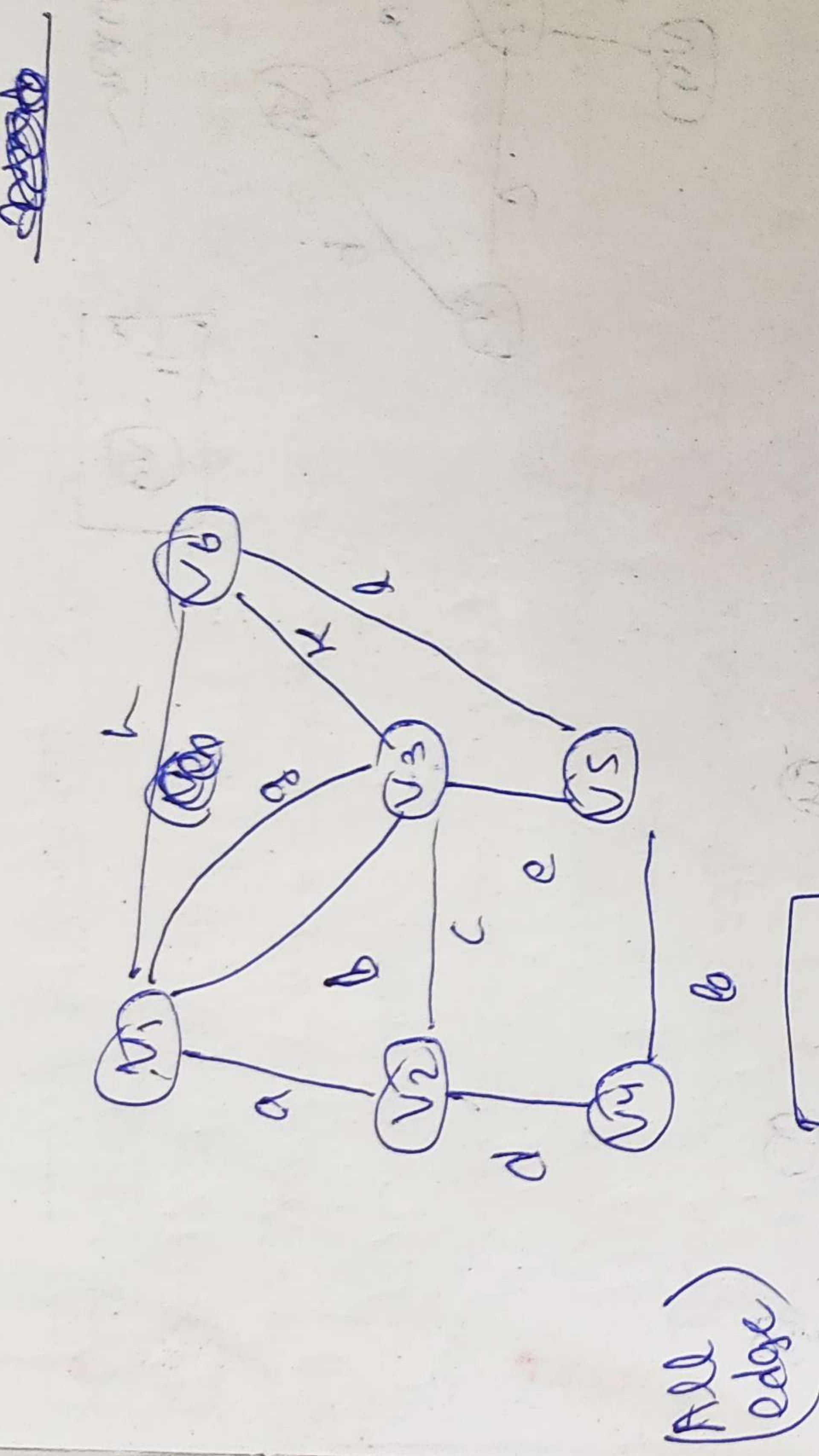
G_2



G_1

G_2

01/12/2029



(All
edges)

$G_1 \cup G_2$

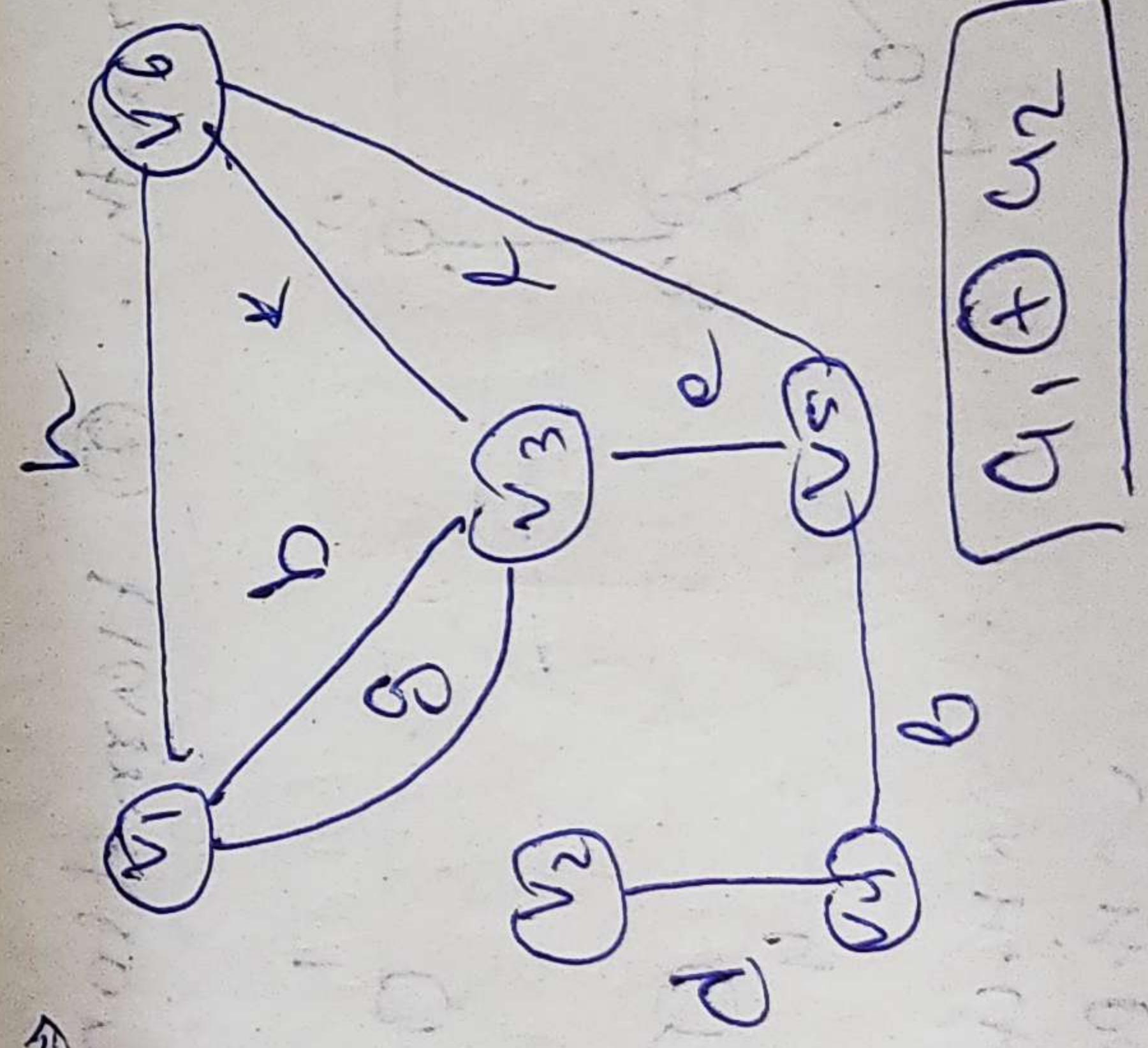
2. Intersection \Rightarrow

(only
common
edges)

$G_1 \cap G_2$

3. Ring sum \Rightarrow

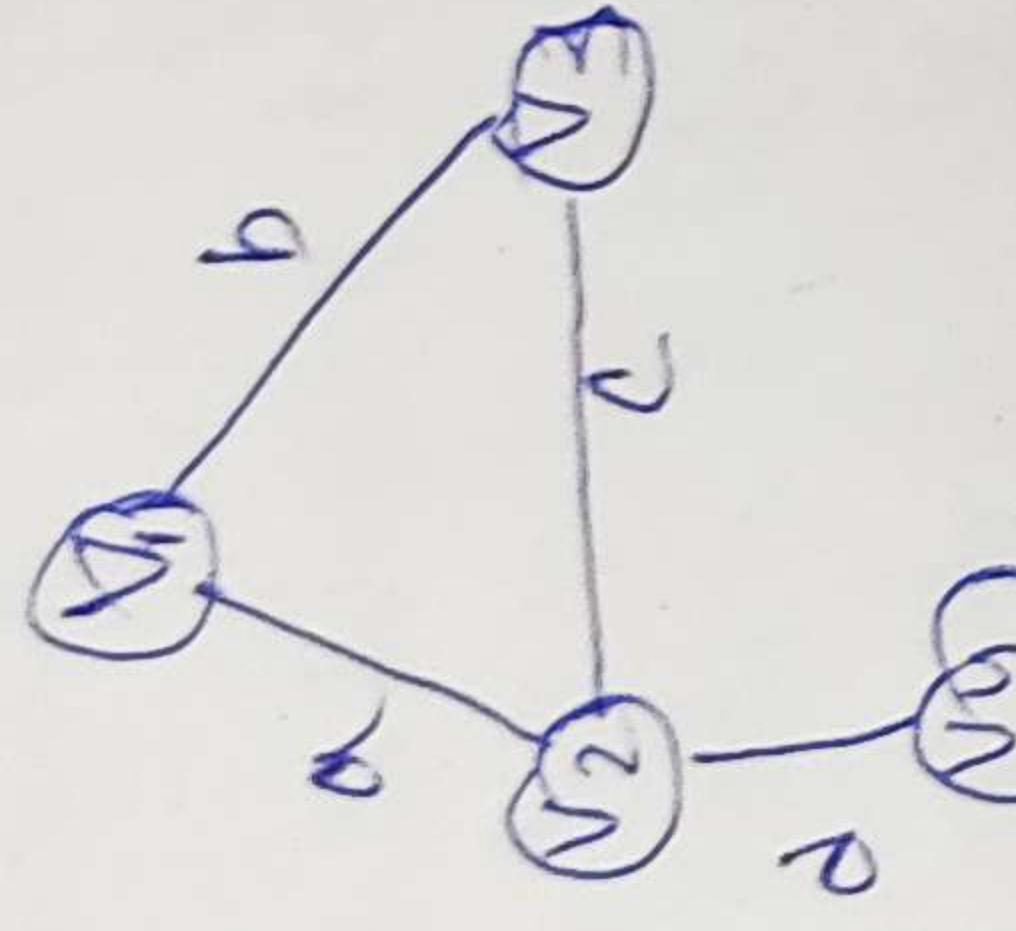
only
uncommon
(edges)



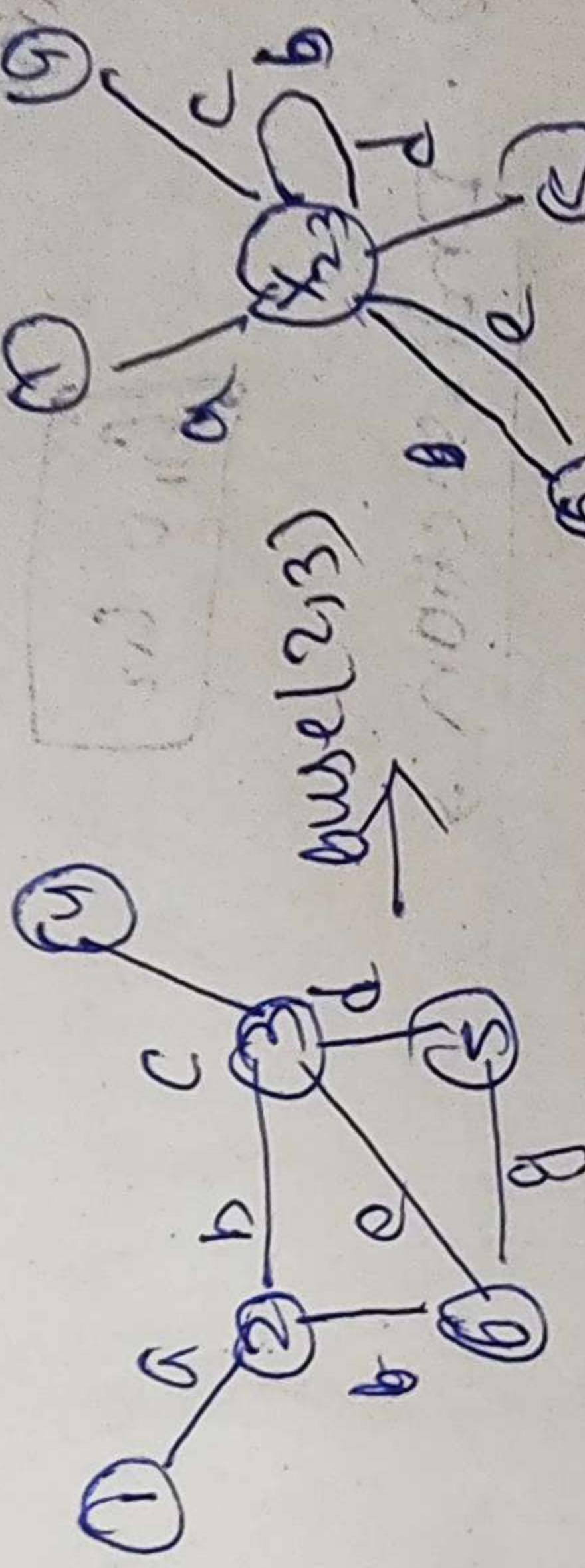
$G_1 + G_2$

4. Dodecahedron \Rightarrow

$$V_1 - V_2$$



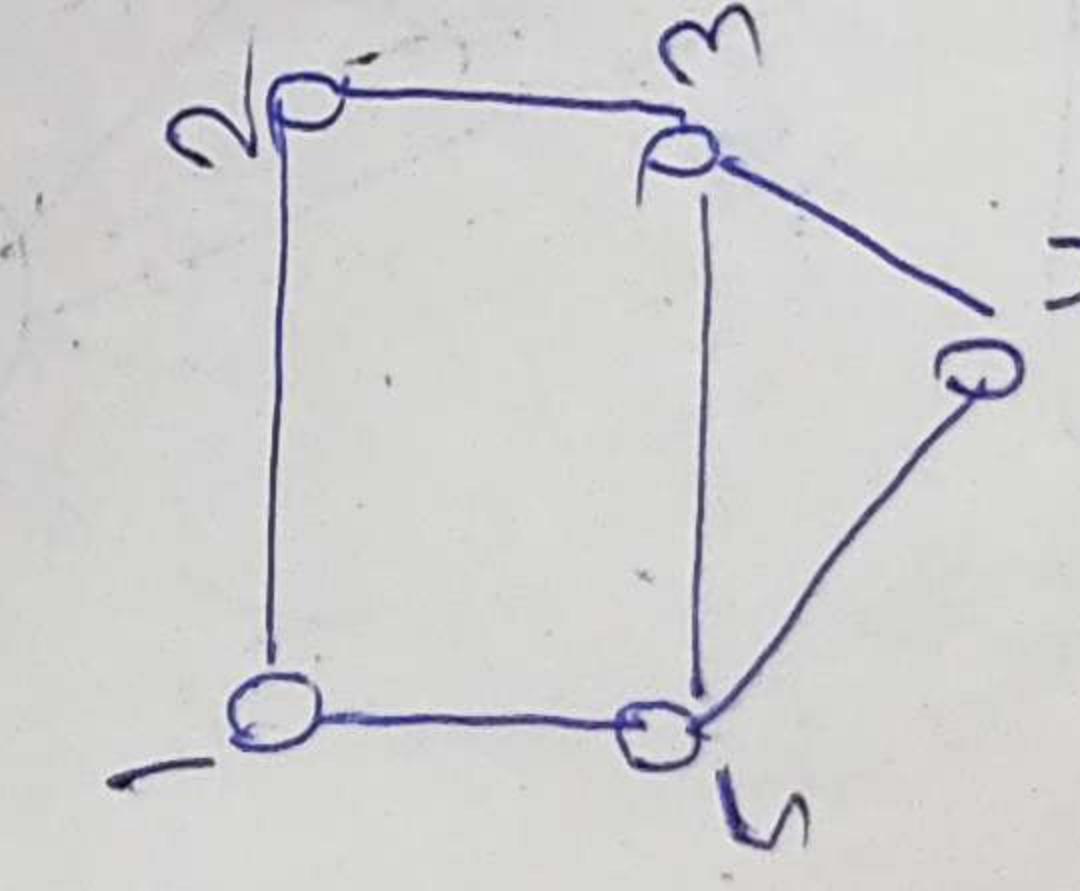
5. Fusion \Rightarrow



* Hamiltonian graph \Rightarrow

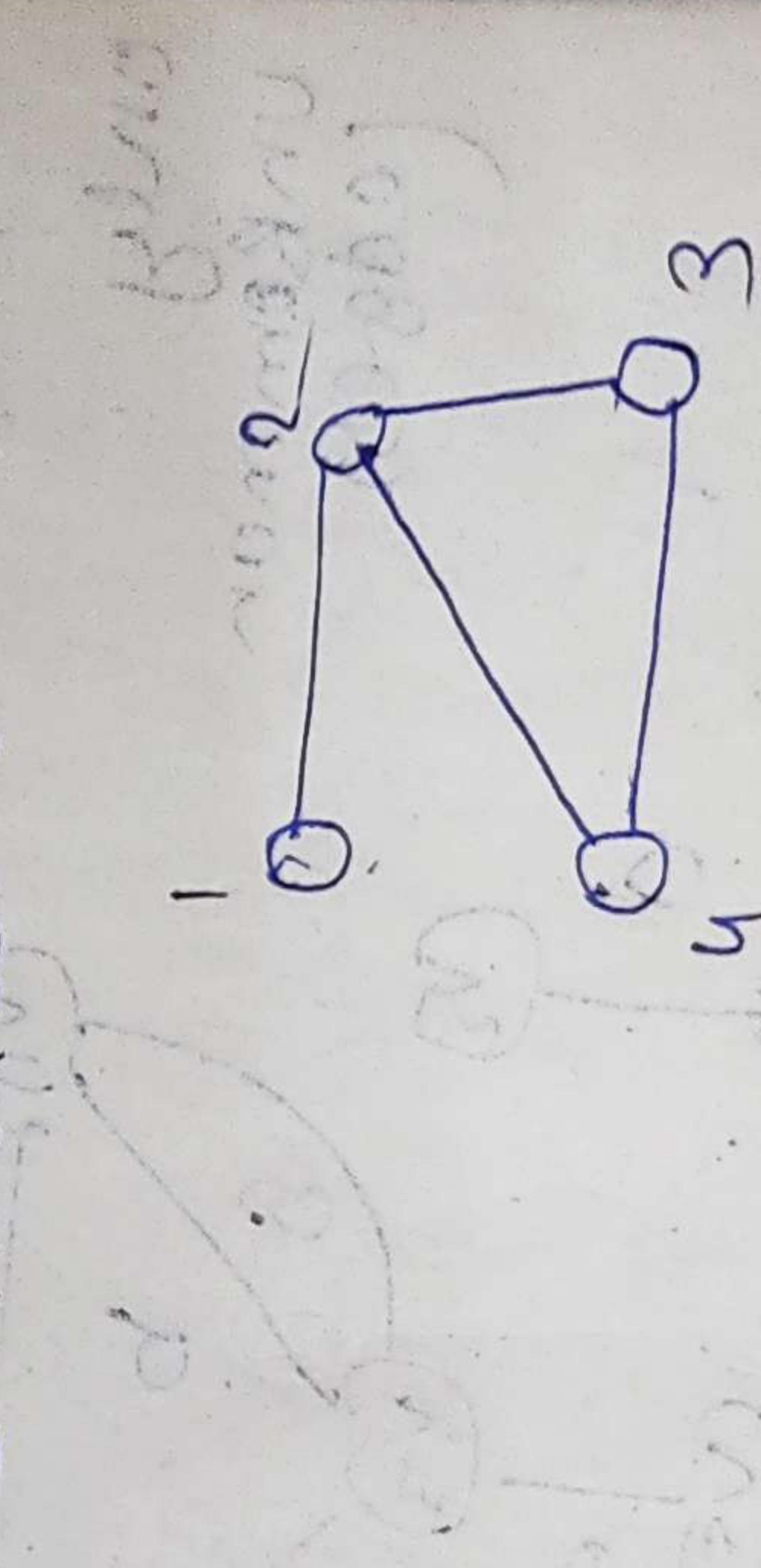
① Difference between Hamiltonian graph and euler graph

② Hamiltonian circuit. ③ Hamiltonian path



\Rightarrow H. Circ \Rightarrow H. Gr.

\checkmark H. Path



\checkmark H. Circ \Rightarrow H. Gr.

\checkmark H. Path

Chandron → 3.C. TRE E

Cooperatives

→ A long time after
I went to work,
I found

A disease must have mainly connective tissue
elements which are derived from the blood vessels and have
a large number of connective tissue fibers and no
vascularity along with them.

Book of the Month Club
and Random House

System 3

Chittagong
District no. 1
of which is
the Chittagong
Division

19

the following
distances
from each other

2-1-4-1-4-1-2-5-3

卷之三

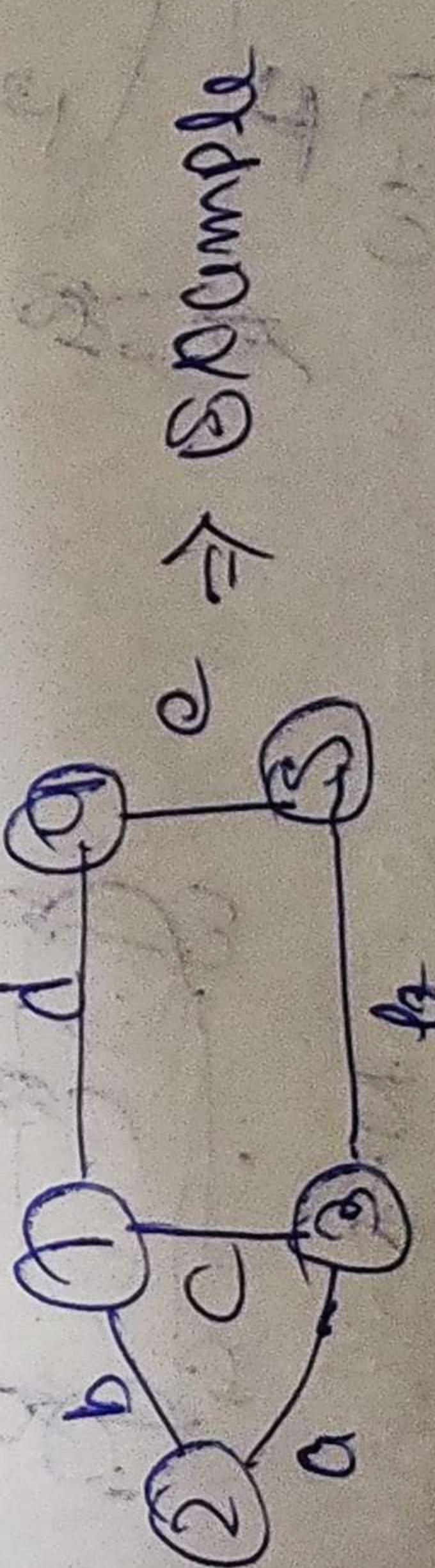
the other side of the country
and the connection between
them is now complete.

Woodstock in Connecticut

Georgian music

333-000002

$(R_1 x) \oplus (R_2 x) \rightarrow (R_1 x) \oplus \uparrow$.
R₁ x = R₁ x →
R₂ x = R₂ x →
R₁ x ⊕ R₂ x →



* Eccentricity \rightarrow $E(G)$ \rightarrow find the distance from v to the furthest vertex in the graph.

* The vertex having lowest eccentricity is

Centre of tree

(Q) Show that a tree can be either monocentric or bicyclic.

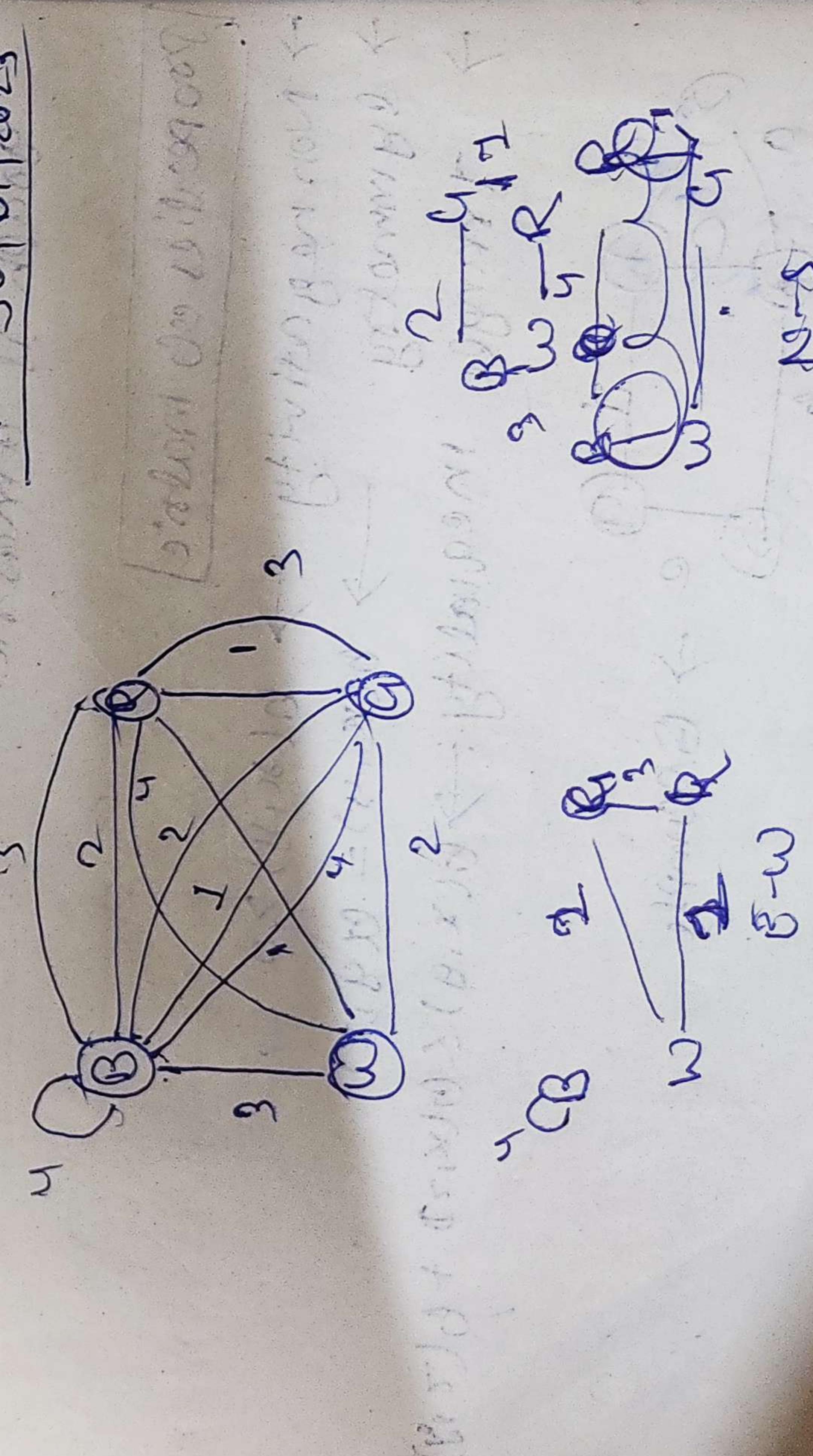
\rightarrow To bind centre before random step by step.

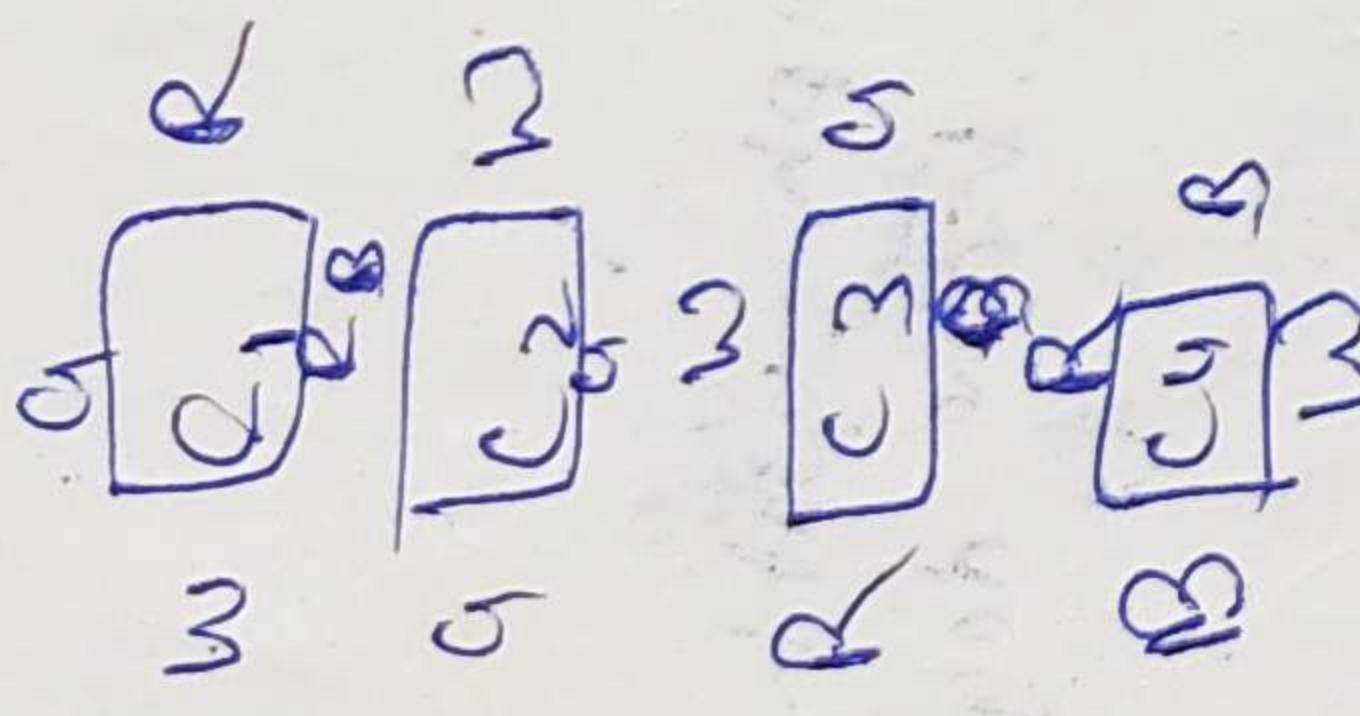
Radius & Diameter

\rightarrow Radius is the eccentricity value of the centre.
 \rightarrow Diameter is the largest path available in tree.

(Q) Show that in a tree R & S Diameter may not be always equal to twice R & S radius.

Date \rightarrow 30/01/2023





Q.) There are 25 telephones in some office. It is possible to connect them with wires so that each telephone is connected with exactly 4 others.

~~It is not possible~~

~~because~~

$$\text{Sum of degrees} = \sum \deg(v)$$

$$20 \times 20 = 25 \times 4$$

$$20 = \frac{25 \times 4}{2}$$

It is not possible

* No. of vertices $= n$
Connected to all
computer.

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

* Maximum degree is equal to no. of ports.

Q.) Determine the number of edges in a graph with 5x vertices, two of which are of degree 4, and n others of odd degree 2.

$$(2 \times n) + (n \times 2) = 20$$

$$e = 8$$

Q.) How many vertices are needed to construct a graph with 5x edges in which every vertex is of degree 2.

Solution

$$2 \times 6 = 12 \times V$$

$$V = 6$$

- Q) Is it possible to construct a graph with n vertices such that 2 of the vertices have degree 3 and remaining have degree 4.

$$\text{Solve} \Rightarrow 2 \times 3 + 4 \times 4 = 2e$$

$$6 + 16 = 2e$$

$$16 = 2e$$

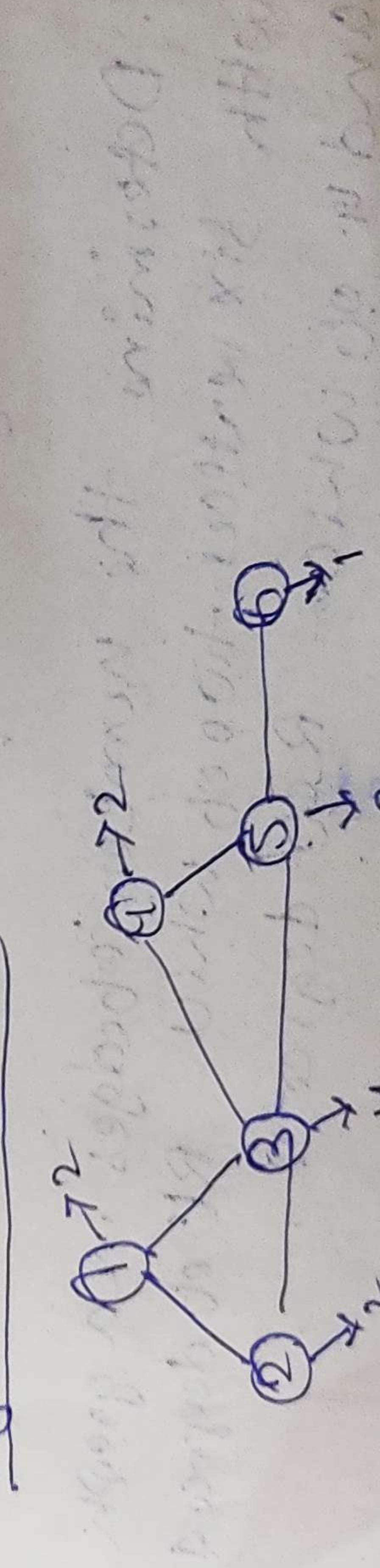
$$e = 8$$

- Q) Is it possible to draw a simple graph with 4 vertices and 7 edges.

$$\text{Solve} \Rightarrow \frac{\text{Max. no. of edges}}{\text{In a simple graph}} = \frac{n(n-1)}{2}$$

$$\text{So} \quad \text{No. of edges} = \frac{2(4)(3)}{2} \\ = 2 \times 3 \times 2 \\ = 12$$

* degree sequence of graph is a sequence of numbers



$$\{1, 2, 2, 2, 3, 4\}$$

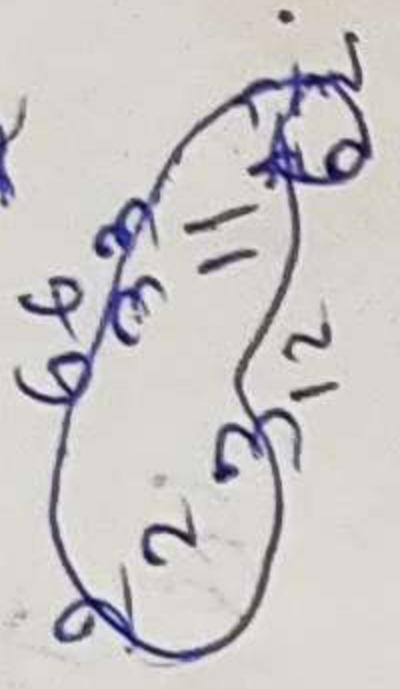
- Q) Can there exists a simple graph with hub degree sequence $\{2, 2, 2, 3, 4\}$

$$\boxed{2+2+3+1 \neq 20} \text{ not possible}$$

$$Q. \quad \{1, 2, 3, 4, 5\} \quad \text{Ans}$$

$$Q. \quad \{2, 4, 6\}$$

$$\frac{1}{13} \quad \text{Ans}$$



- (Q) A tree has n vertices with odd degree 2, and m vertices with even degree 2. Determine no. of edges and vertices in the tree.

Solution \rightarrow $n - \text{vertices}$ / $m - \text{edges}$

$$\text{Edges} = \frac{n}{2} + m - 2$$

$$\text{Vertices} = 2m$$

$$\text{Degrees} \times n = 2 \times (m-1)$$

$$\text{Edges} = m - 2$$

$$\frac{n}{2} + m - 2 = m$$

$$\text{Degrees} \times n = 2 \times (m-1)$$

$$\text{Edges} = m - 2$$

$$\frac{n}{2} + m - 2 = m$$

$$\text{Degrees} \times n = 2 \times (m-1)$$

$$\text{Edges} = m - 2$$

$$\frac{n}{2} + m - 2 = m$$

$$\text{Degrees} \times n = 2 \times (m-1)$$

$$\text{Edges} = m - 2$$

$$\frac{n}{2} + m - 2 = m$$

Properties

- There is exactly one vertex with degree 1, or it is rest of the vertices will be degree odd, i.e. in called binary rooted tree (BRT). The root node vertex (or) is known as the root.
 2. Rooted tree

- (i) the no. of vertices in a BRT is odd.
(ii) the no. of odd degree vertices in a tree is always even.

vertices is n degree (a)
 $n-1$, " " $n-1$ degree (a)

3) The main wall (E) has
vertical recesses on both sides.
Total height
from ground to top
is 1.8 m. Roof
is made of corrugated iron.

2. $\Delta \leftarrow \text{ab} \cdot \text{abc} \cdot \text{abc} \cdot \text{ab}$

میں اپنے بھائی کو پہلے دیکھا۔

$$\sum \Delta(\lambda^g) = \Delta x_1 + (\Delta x_2 + (\Delta x_3 + \dots + \Delta x_{n-p-1})x_n) + \Delta x_n$$

1st
2nd

2-1 (195) Bog II
High & Dry
↑

Highway 101
Montgomery

John G. Steele

10.

How the idea of Counting goes
from 0. How many vehicles can be drawn
using 0. It is no more than 10.
Counting numbers are written in
horizontal rows. Horizontal rows
are called rows. Vertical columns
are called columns. Columns are
written vertically. Vertical columns
are called columns.

m^2 Sogedale sheep can be down.

Aug 19, 240

→ Pandas have a unique diet consisting mainly of bamboo leaves.

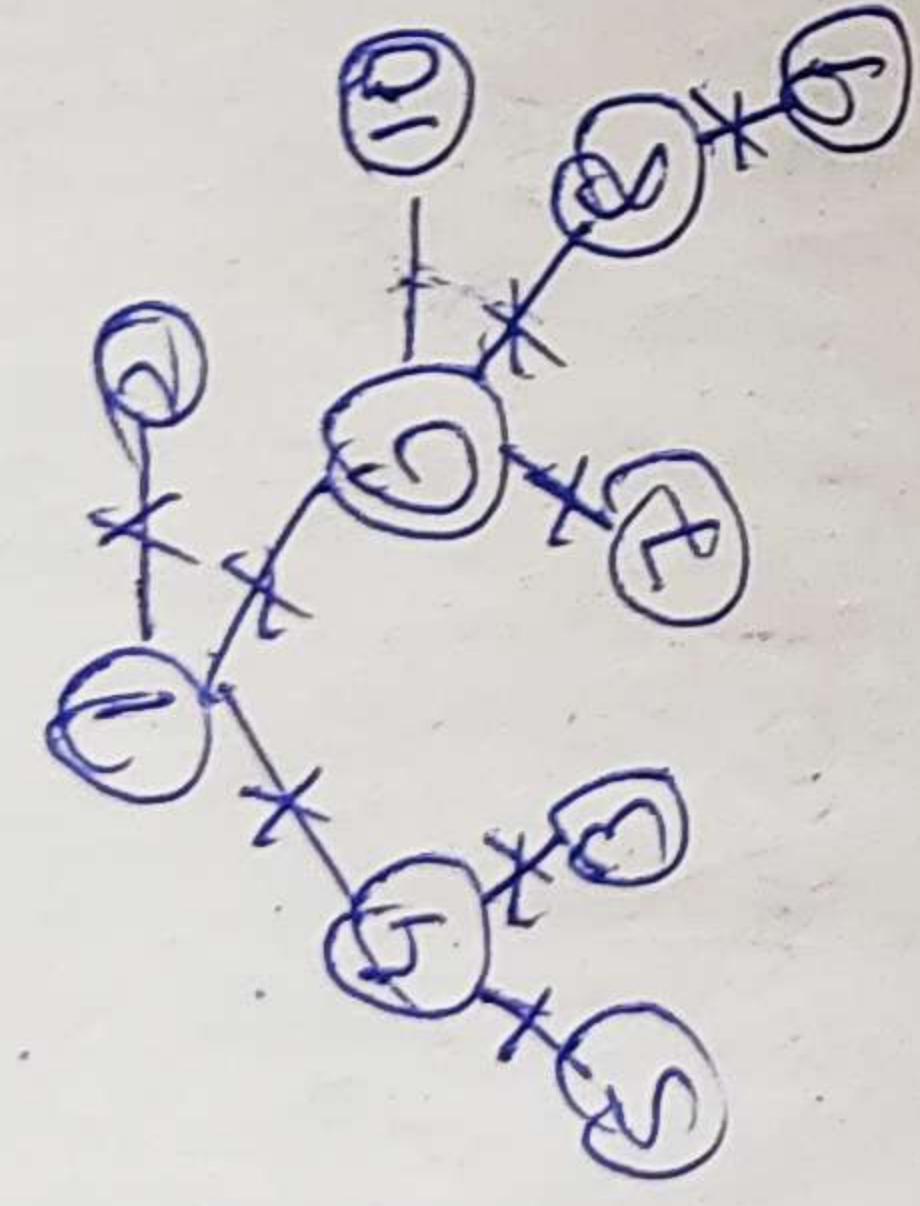
animal one edge
(3-2)

A vertical column of handwritten numbers and arrows. The numbers are arranged as follows: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100. Above each number, there is a blue arrow pointing to the right. To the right of the column, there is a vertical sequence of numbers from 1 to 100, with some numbers crossed out.

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

→ Depth-First Search (DFS)

- Q). Given the given tree find out DFS and BFS of
the constructed tree and also
a) Construct the ordered set.



$$\text{Q. DFS} = \{ 1, 2, 4, 8, 5, 10, 6, 3, 7, 12, 14, 15 \}$$

$$\text{Q. BFS} = \{ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 \}$$

$$\text{Q. PDS} = \{ 1, 2, 4, 8, 5, 10, 6, 3, 7, 12, 14, 15 \}$$



* Spanning tree

- Q) Show that a Hamiltonian path is a spanning tree.

→ branch $(n-1)^2$
→ chord $(e-n+1)$

Q) What is a spanning forest.

Q) Shows that the distance between two spans is
equal to a graph isomorphic.

Ans $d(T_1, T_2) = m \neq n$. If changes in T_1 .

* Matrix tree theorem

(g) Laplacian matrix

$$\text{if } i \neq j$$

number of its one adjacent node, then $a_{ij} = k$

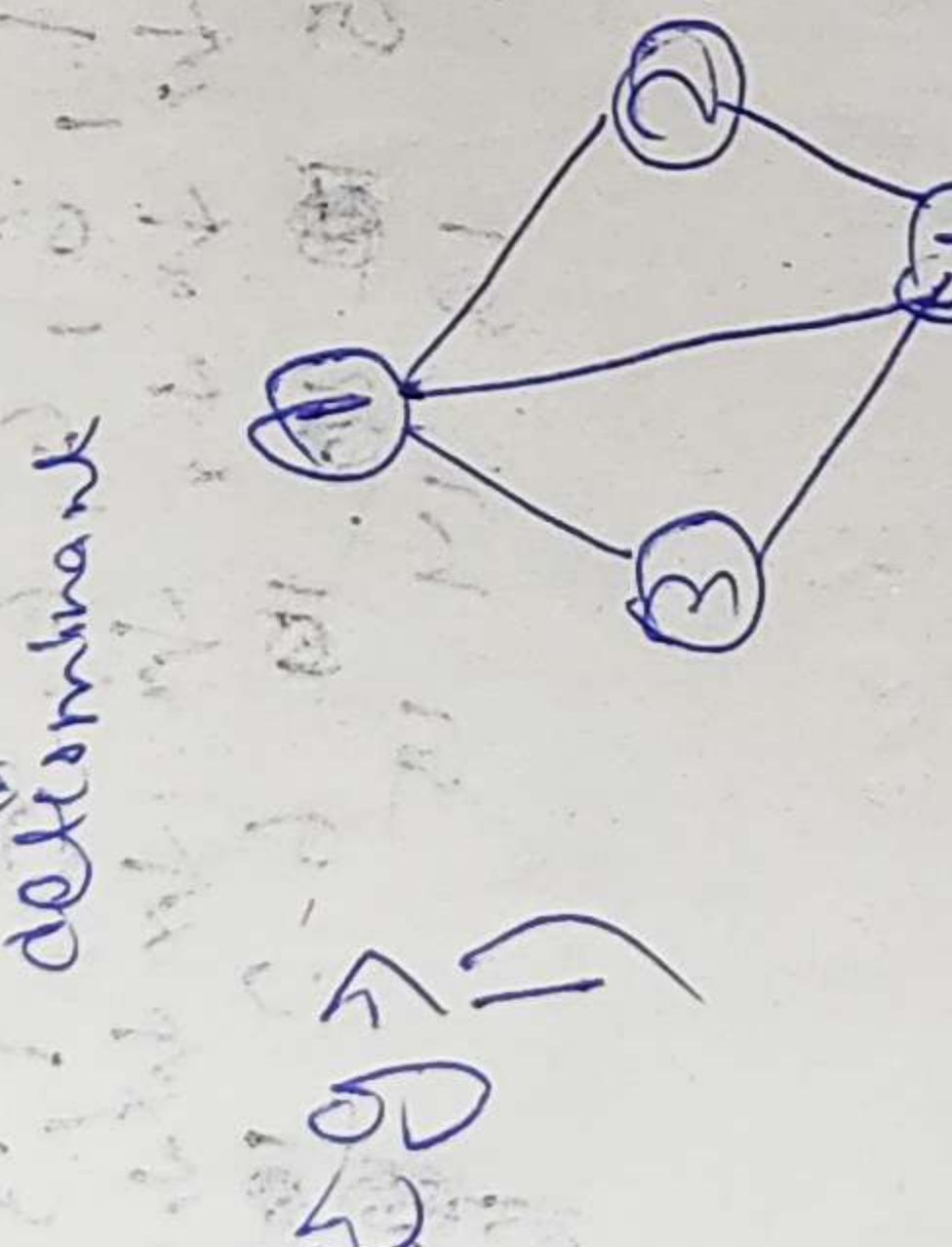
Otherwise, $a_{ij} = 0$

2. signs of a_{ij}

$a_{ij} = \text{degree of vertex } i$ in G_j

$\Omega' \rightarrow \text{reduced } \Omega \text{ with } 1 \text{ row, } 1 \text{ column.}$

~~det (Ω')~~ \rightarrow Now, we get 1 in Ω' determinant



$$\Omega' = \begin{bmatrix} 3 & -1 & 0 \\ 2 & -1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$$

delete any row and any column.

$$\text{but still } \Omega' \text{ is not diag. } \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & -1 \\ -1 & -1 & 3 \end{bmatrix}$$

$$\det(\Omega') = 2 \cdot 2 \cdot (6 - 4) + 0 \cdot (4 - 0) \\ (1 \times 1 \times 0) + 0 \cdot (0 \times 1) = 4$$

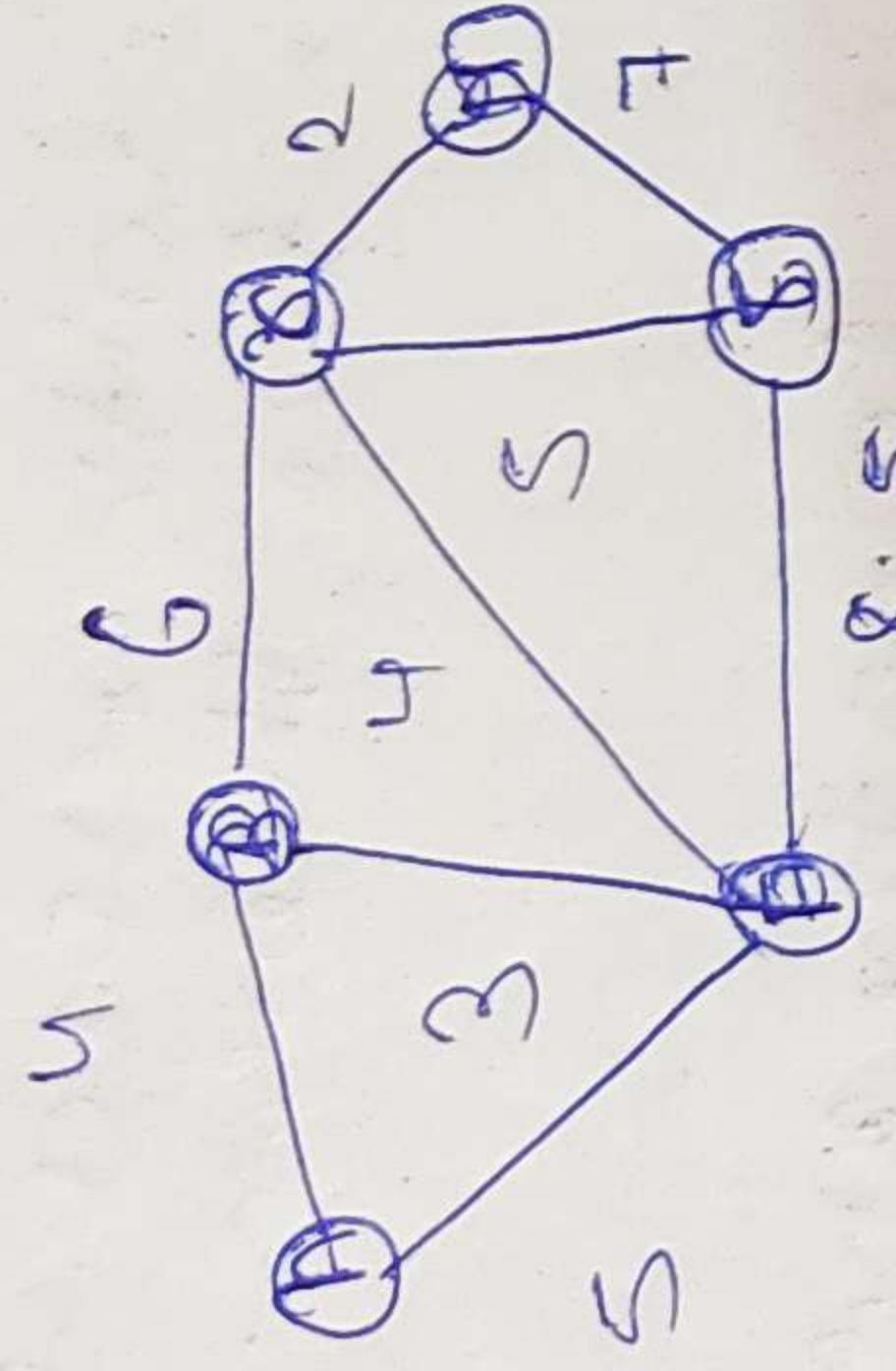
$$\text{Laplace's formula} \quad \frac{1}{2} (0 - 2) = 2$$

maximum weight spanning tree is 8.

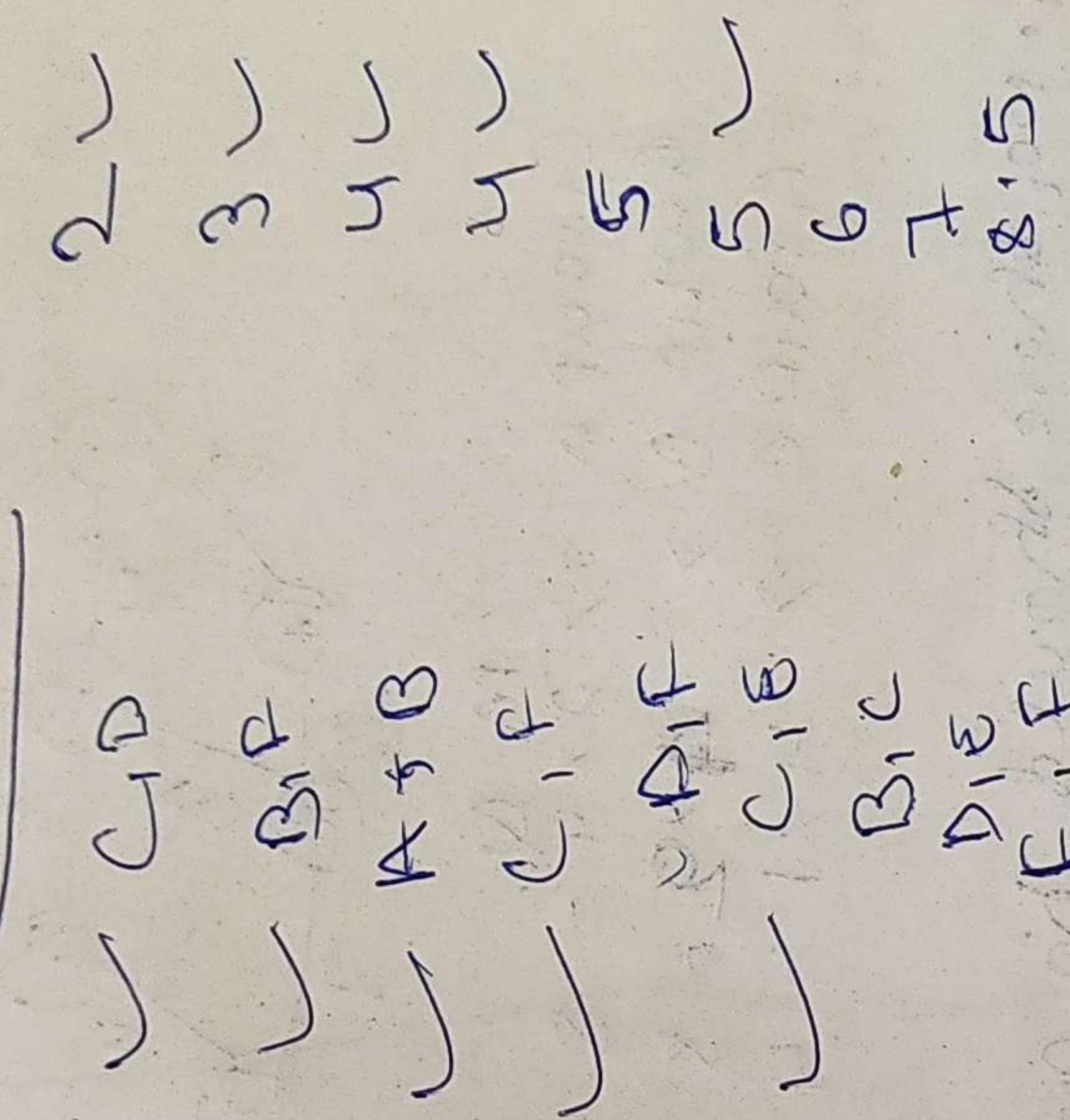
Method 2: $\Omega' = \begin{bmatrix} 3 & -1 & 0 \\ 2 & -1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$

method 3: $\Omega' = \begin{bmatrix} 3 & -1 & 0 \\ 2 & -1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$

Minimum Spanning Tree

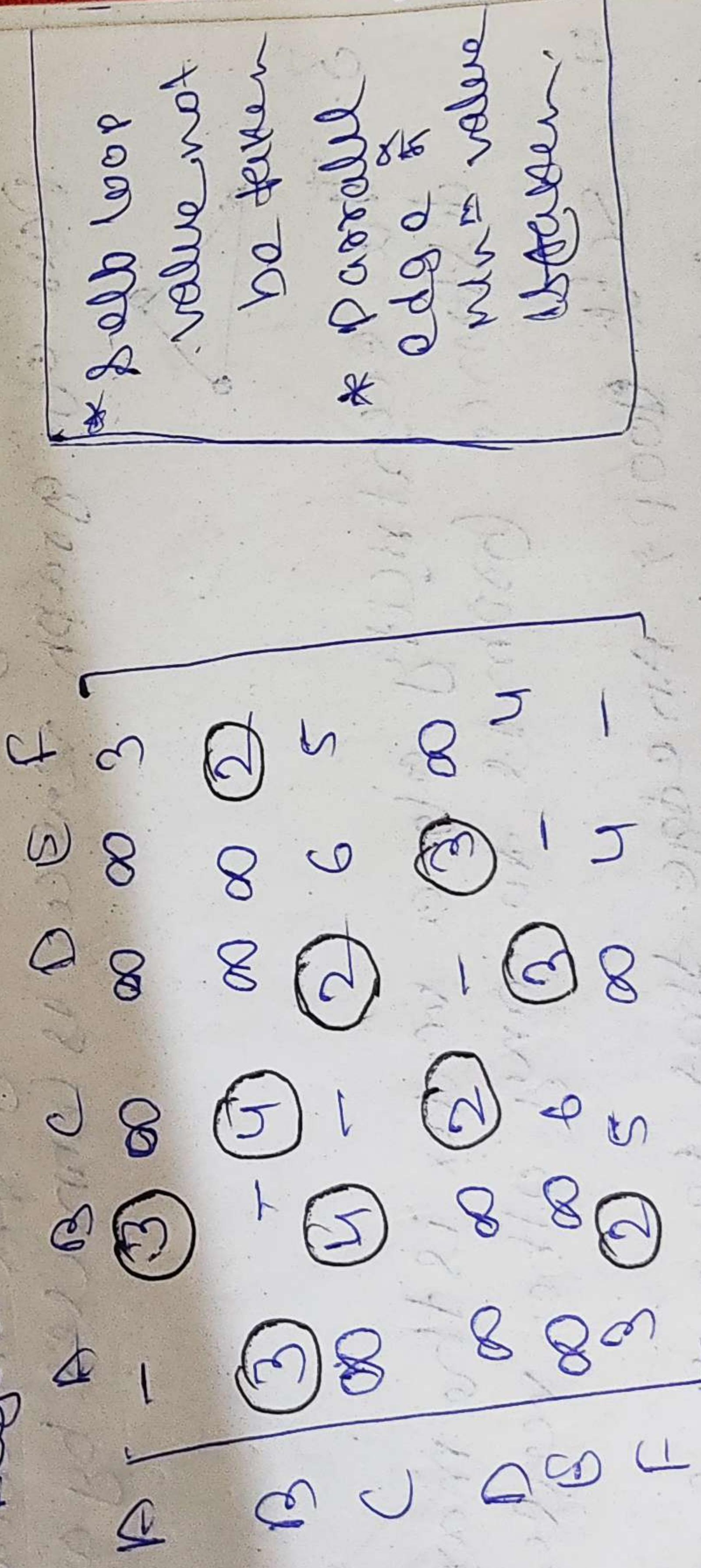


Kruskal's Algorithm \rightarrow vertex name disjoint

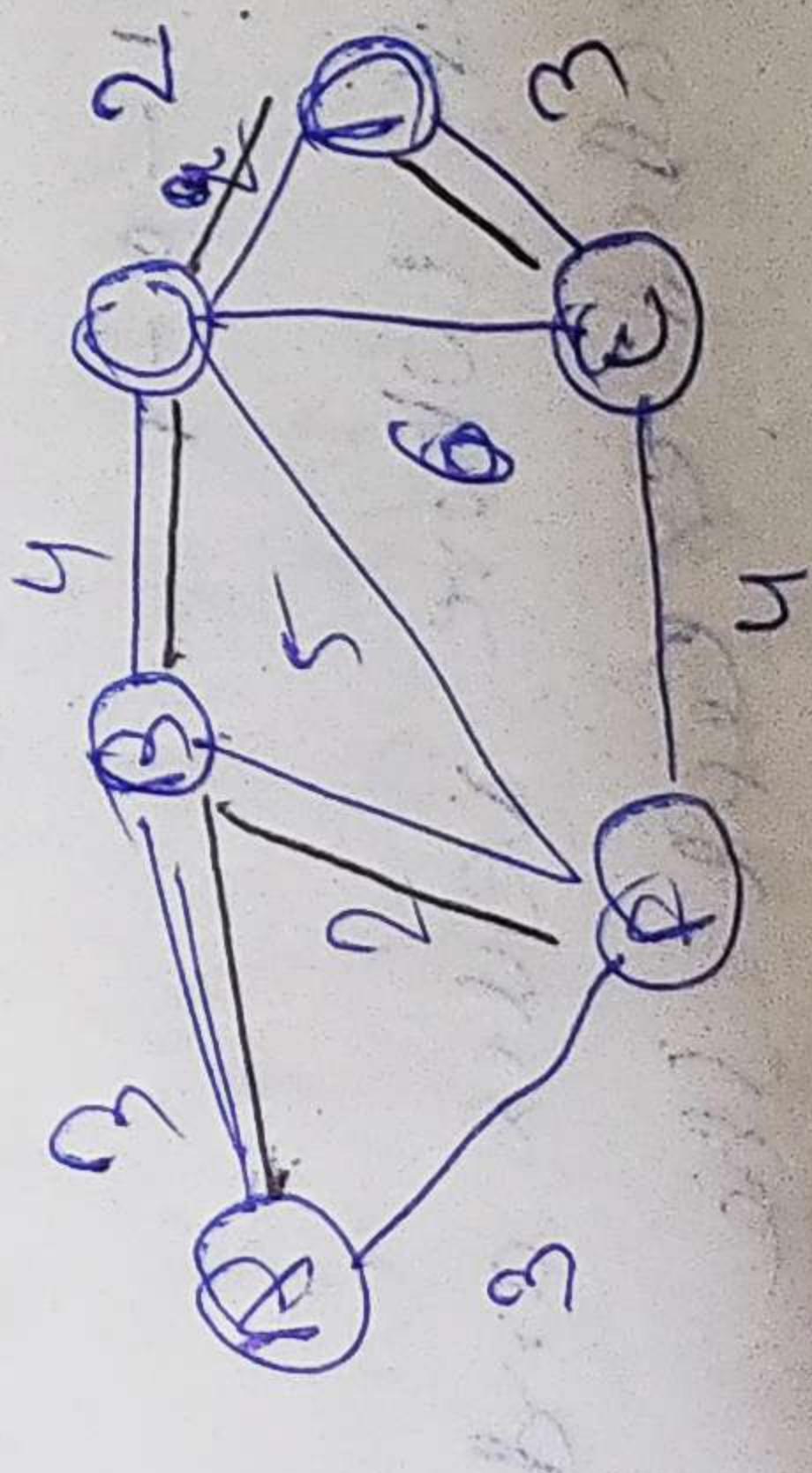


minimum spanning tree \rightarrow 18
(MST)

Dinic's Algorithm \rightarrow

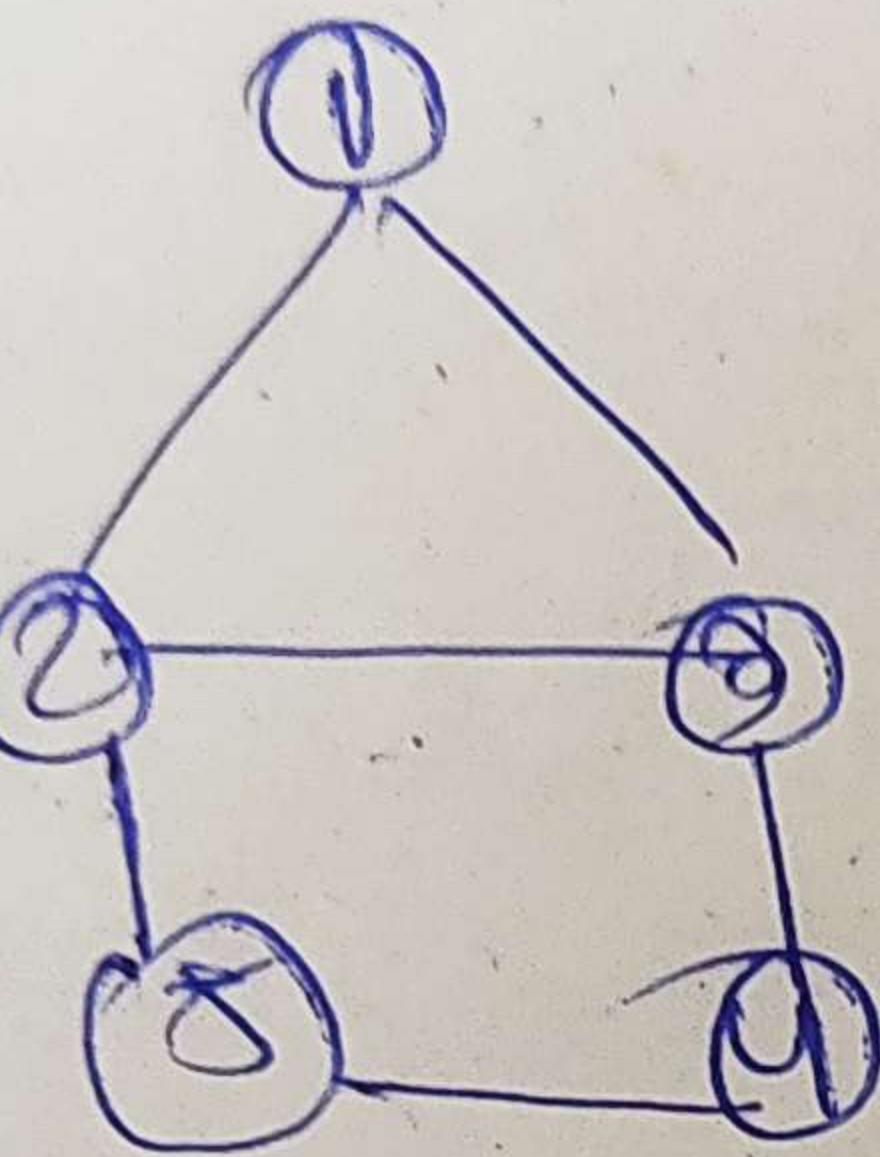


$$x =$$



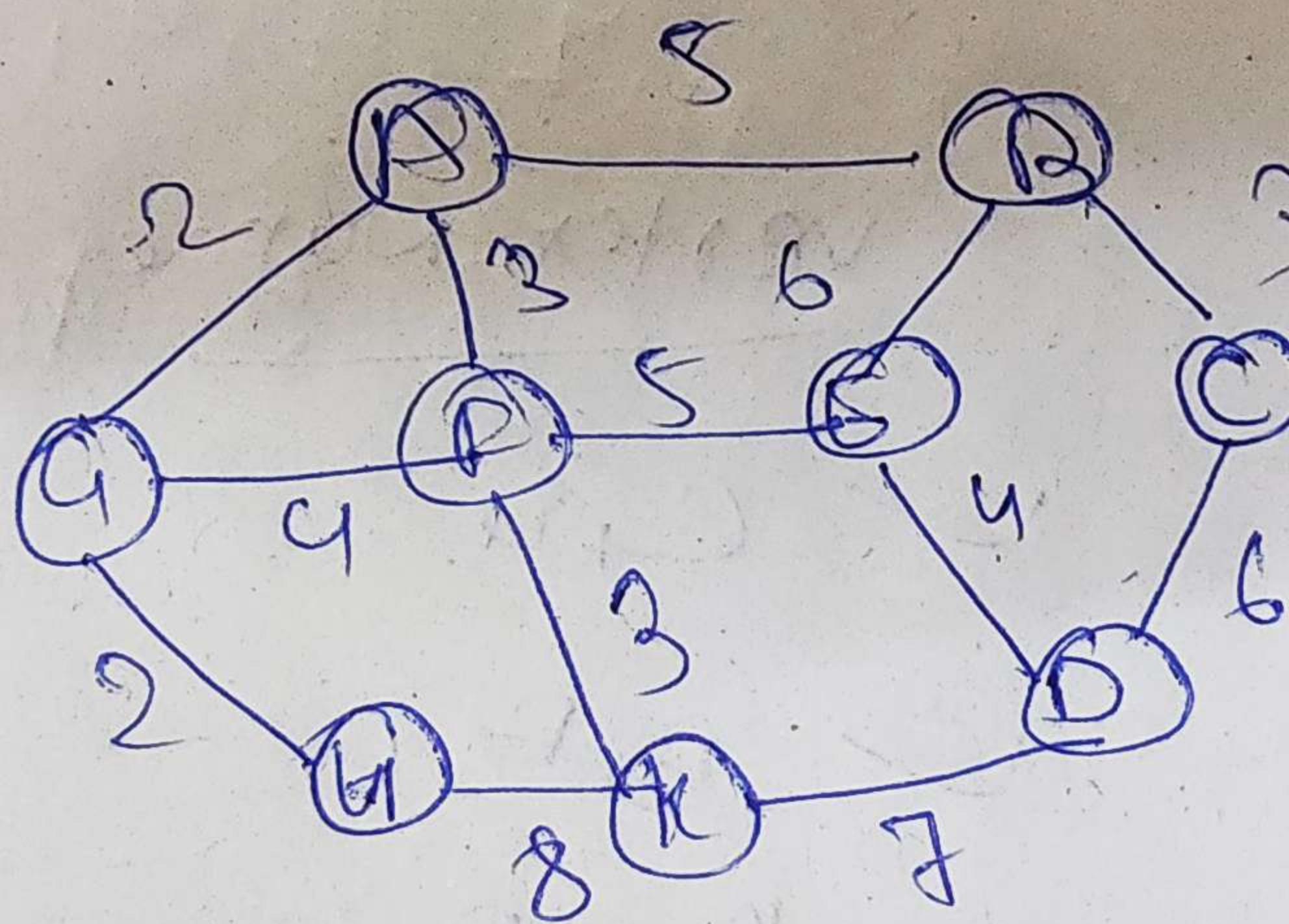
MST \rightarrow 3 + 2 + 4 + 2 + 3 =

(B)



From the given graph find
out the no. of spanning tree
possible with respect to
matrix tree theorem.

(Q)



From the given graph
find out MST using
Roth's algorithm
separately. What is the
weight of MST.

M.Q.
GROUP A $\Rightarrow 2 \times 4 = 8$
GROUP B $\Rightarrow 4 \times 2 = 8$
GROUP C $\Rightarrow 4 \times 1 = 4$

Germany Isomorphism
Dice
Doubtless
Matrix theory
Graphs
writing