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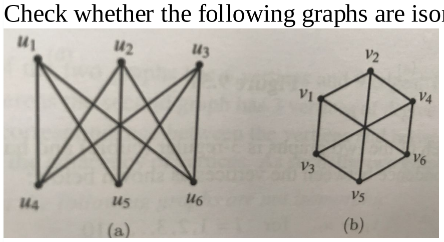
Internal Assessment Test II – Feb 2026

Sub:	Mathematical Foundation for Computer Applications				Sub Code:	MMC102	Branch:	MCA
Date:	17/02/2026	Duration:	90 minutes	Max Marks: 50	Date:	17/02/2026		Duration:

<u>Note: Answer FIVE FULL Questions, choosing ONE full question from each part.</u>

		MARKS	CO	RBT
	PART I			
1	Define the following with an example for each: (i) Complete graph (ii) Regular graph (iii) Null graph (iv) Spanning Subgraph.	[10]	CO2	L1
	OR			
2	Determine the order $\lvert V \rvert$ of the graph $G = (V, E)$ in the following cases: (i) G is a cubic graph of 9 edges. (ii) G is regular with 15 edges. (iii) G has 10 edges with 2 vertices of degree 4 and all other vertices of degree 3.	[10]	CO2	L3
	PART II			
3	Check whether the following graphs are isomorphic.	[10]	CO3	L3



OR

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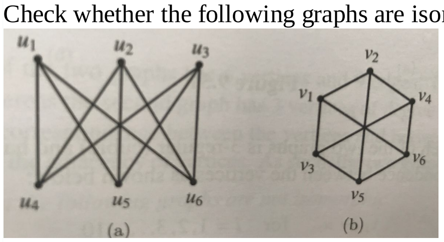

OR

4	Does there exist a simple graph with following degree sequence? Give reasons. (i) 0, 2, 2, 3, 4 (ii) 1, 1, 2, 3 (iii) 0, 2, 2, 2 (iv) 2, 2, 4, 6, 6	[10]	CO3	L2
	PART III			
5	Define Euler Circuit. Explain Konigsberg Bridge Problem.	[10]	CO4	L1
	OR			
6	Let A={1, 2, 3, 4} and R be the relation on A defined by ‘xRy if and only if x divides y’. Write down R as a set of ordered pairs. Draw the digraph of R. Find in-degree and out-degree of each vertex.	[10]	CO3	L2
	PART IV			
7	List and explain different operations on graphs.	[10]	CO3	L2
	OR			
8	Let A={1, 2, 3, 4, 6} and R be a relation on A defined by ‘aRb if and only if a is a multiple of b’. Write down R as a set of ordered pairs. Draw the digraph of R. Is this digraph of relation R reflexive? Is it symmetric?	[10]	CO3	L3
	PART V			
9	Find the Chromatic polynomial and Chromatic number for the cycle C_4 of length 4.	[10]	CO4	L3
	OR			
10	Define Hamilton Circuit, Hamilton Path, Symmetric Digraphs and Asymmetric Digraphs with an example for each.	[10]	CO3	L2

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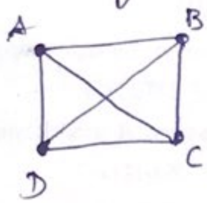
Discrete Mathematics & Graph Theory (MMC102)

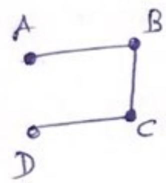
IAT 2 - MCA I Sem

10) Hamilton Circuit in a connected graph is defined as a closed walk that traverses every vertex of G exactly once, except the starting vertex at which the walk also terminates.



Here, ABCDA is a Hamilton circuit

Hamilton Path is an open walk that traverses every vertex of G exactly once.



Here, ABCD is a path.

<u>Symmetric Digraph</u> - Digraphs in which for every edge (a,b) there is also an edge (b,a) is called symmetric digraph.

Eg:-

<u>Asymmetric Digraph</u> - Digraphs that have at most one directed edge between a pair of vertices, but are allowed to have self loops are called asymmetric.

Eg:-

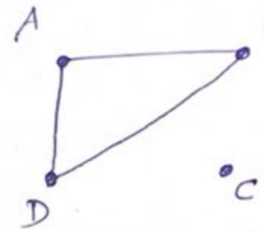
4. ~~Spanning~~

(iii) 0, 2, 2, 2

Sum of the degrees $= 0+2+2+2 = 6$, even

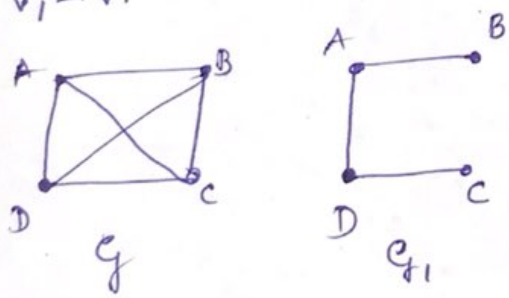
So, we can have a simple graph with the above degree seq.

Eg :-



$G_1(V_1, E_1)$

1 (iv) Spanning subgraph - A graph G_1 is said to be a subgraph of graph $G(V,E)$ if G_1 is a subgraph of G and $V_1 = V$.

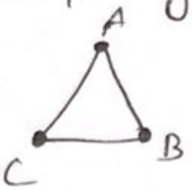


Here, G_1 is a subgraph of G.

(i) (1)

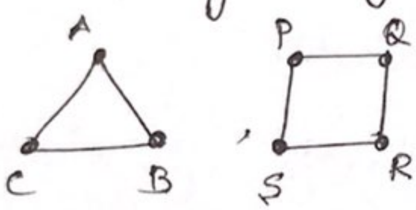
Complete Graph: A simple graph of order $n \geq 2$ where there is an edge between every pair of vertices is called complete graph.

Eg :-



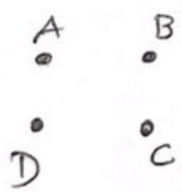
(ii) Regular Graph: A graph where every vertex is of same degree, say k, is called a regular graph or k-regular graph.

Eg :-



(iii) Null graph : A graph having only vertices but no edges is called a null graph. (In other words, it is a graph where degree of every vertex is zero.)

Eg :-



(3)

Both the graphs G_1 & G_2 have 6 vertices.

———— " ———— have 9 edges.

———— " ———— have 6 vertices of degree 3.

Vertex Mapping

$u_1 \leftrightarrow v_1$
$u_2 \leftrightarrow v_5$
$u_3 \leftrightarrow v_3$
$u_4 \leftrightarrow v_4$
$u_5 \leftrightarrow v_2$
$u_6 \leftrightarrow v_6$

Edge Mapping

$\{u_1, u_4\} \leftrightarrow \{v_1, v_4\}$
$\{u_1, u_5\} \leftrightarrow \{v_1, v_2\}$
$\{u_1, u_6\} \leftrightarrow \{v_1, v_6\}$
$\{u_2, u_4\} \leftrightarrow \{v_5, v_2\}$
$\{u_2, u_5\} \leftrightarrow \{v_5, v_2\}$
$\{u_2, u_6\} \leftrightarrow \{v_5, v_6\}$
$\{u_3, u_4\} \leftrightarrow \{v_3, v_4\}$
$\{u_3, u_5\} \leftrightarrow \{v_3, v_2\}$
$\{u_3, u_6\} \leftrightarrow \{v_3, v_6\}$

∴ there exists a 1-1 mapping b/w the vertices & edges of G_1 & G_2. ∴ They are isomorphic.

2

Let $|V| = n$

(i) Here $|E| = 9$, Degree of every vertex is 3.

From Hand Shaking Property,

$$\sum deg(v_i) = 2|E|$$
$$3n = 2(9)$$
$$n = 6$$

(ii) ~~Let~~ $|E| = 15$. Let the degree of every vertex be k.
Given↑

From Hand-Shaking Property,

$$\sum \deg(v_i) = 2|E|$$

$$kn = 2(15)$$

$$k = \frac{30}{n}$$

n must be +ve divisor of 30.

$\therefore n = 1, 2, 3, 5, 6, 10, 15, 30.$

(iii) Here $|E| = 10$.

From H-S property,

$$\sum \deg(v_i) = 2|E|$$

$$2(4) + (n-2)3 = 2(10)$$

$$8 + 3n - 6 = 20$$

$$3n = 18$$

$$n = 6$$

4

(i) Sum of the degrees of all vertices $= \sum deg(v_i)$

$= 0+2+2+3+4$

$= 11$ which is odd.

So, we can't have a simple graph with the given degree seq.

(ii) $\sum deg(v_i) = 1+1+2+3 = 7$ which is odd.

So, it is not possible to have a simple graph with the given degree sequence.

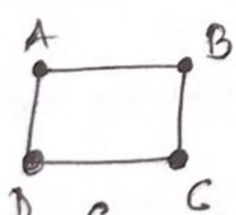
(iii) $\sum deg(v_i) = 2+2+4+6+6 = 20$ which is even.

But in a simple graph with 5 vertices, degree of a vertex can not be more than 4. Degree can be 6 only when there is a multiple edge or loop or both. Hence we can not have a simple graph with the given degree sequence.

5

Euler Circuit: Consider a connected graph G. If there is a closed walk in G that contains all the edges of G without any repitition then that closed walk is called Euler Circuit.

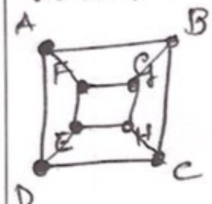
Eg:-



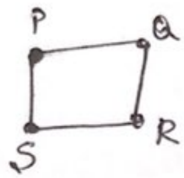
G_1

ABCDA in this graph G_1 is an Euler Circuit.

Hamilton Circuit in a connected graph is defined as a Closed walk that traverses every vertex of G exactly once, except the starting vertex which is also the end vertex. Eg:



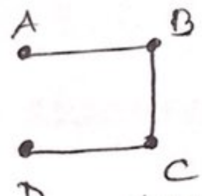
Here AFGBCHEDA is a Hamilton ~~walk~~ circuit



PQRSP is a Hamilton ~~Path~~ circuit.

Hamilton Path is an open walk that traverses every vertex of G exactly once.

Eg: –

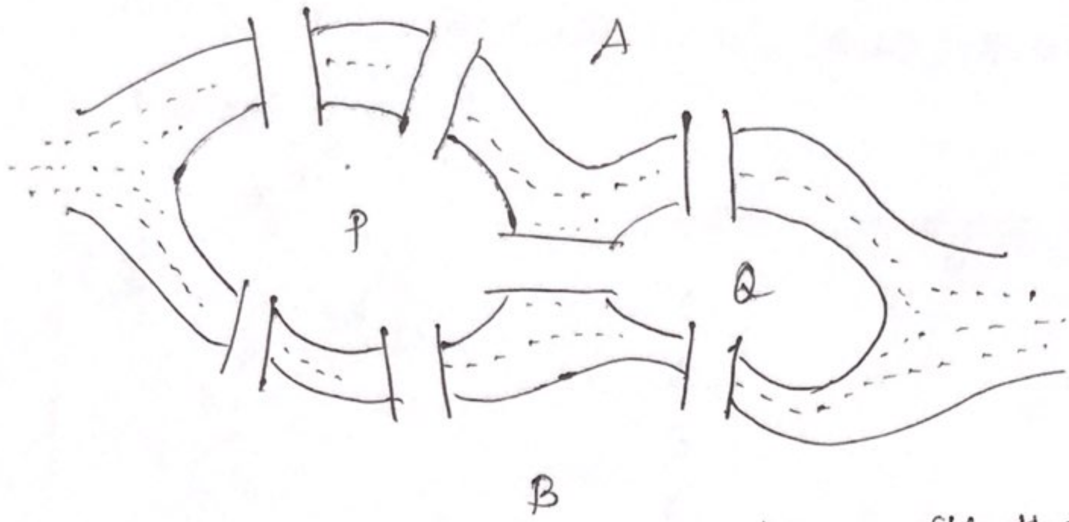


Here, ABCD is a Hamilton Path.

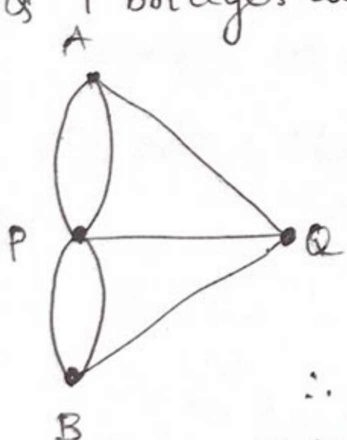
5 +

Konigsberg Bridge problem:

In 18^{th} century, in a city named Konigsberg, a river flowed named Pregel river which divides city into 4 parts – 2 banks of the river and 2 islands. 4 land areas were connected by 7 bridges. Citizens of the city posed a problem – "by starting at any of the four land areas, can we return to that area after crossing each bridge exactly once?" This problem is known as Konigsberg Bridge problem.



In 1736, Euler analyzed the problem with the help of a graph & gave the solution. Denote the land areas as A, B, P, Q as shown in the diagram. Construct a graph by treating the four land areas as four vertices & 7 bridges as edges connecting the vertices.



We note that in this graph

$$\deg(A) = \deg(B) = \deg(Q) = 3$$

$$\deg(P) = 5, \text{ not even.}$$

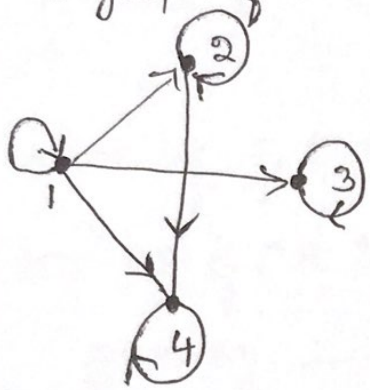
$\therefore$ the graph does not have an Euler circuit

Hence, it is not possible to walk over each of the seven bridges exactly once and return to the starting point.

6

$R = \{(1,1), (1,2), (1,3), (1,4), (2,2), (2,4), (3,3), (4,4)\}$

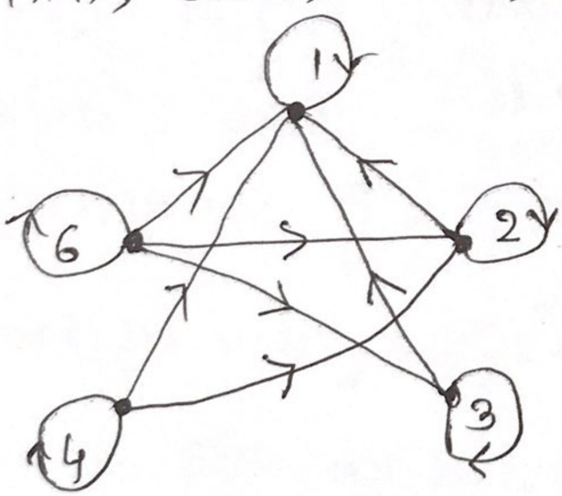
Digraph of R



Vertex	In-degree	Out-degree
1	1	4
2	2	2
3	2	1
4	3	1

8

$R = \{(1,1), (2,1), (2,2), (3,1), (3,3), (4,1), (4,2),$
$(4,4), (6,1), (6,2), (6,3), (6,6)\}$



We know that

a divides a, $\forall a \in A$.
$\therefore (a,a) \in R$
There is a loop at every vertex.

$\therefore$ Digraph (relation) is reflexive.

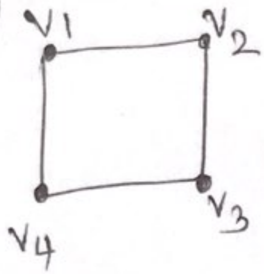
If a is a multiple of b.
Then b is not a multiple of a for $a \neq b$.

$\Rightarrow$ If $(a,b) \in R$ then $(b,a) \notin R$

If (a,b) is an edge then (b,a) is not an edge in the graph.

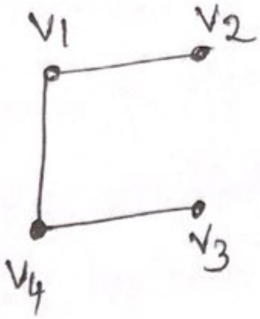
$\therefore$ It is not symmetric.

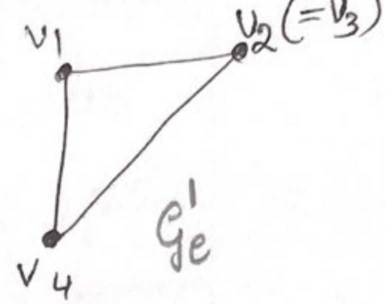
9



A cycle of length 4 is shown in this Fig. Let's call it G. Let $\{v_2, v_3\}$ be e.

Then G_e is





G_e is a path with 4 ~~pe~~ vertices.

$\therefore P(G_e, \lambda) = \lambda(\lambda-1)^3$

G'_e is a complete graph with 3 vertices, K_3.

$$P(G'_e, \lambda) = \lambda(\lambda-1)(\lambda-2).$$

Using decomposition theorem,

$$P(C_4, \lambda) \equiv P(G, \lambda) = P(G_e, \lambda) - P(G'_e, \lambda)$$

$$= \lambda(\lambda-1)^3 - \lambda(\lambda-1)(\lambda-2)$$

$$= \lambda^4 - 4\lambda^3 + 6\lambda^2 - 3\lambda$$

This is the chromatic polynomial for the given cycle.

Operations on Graphs

7)

* Consider two graphs $G_1 = (V_1, E_1)$ & $G_2 = (V_2, E_2)$.

Then the union of G_1 & G_2, denoted by $G_1 \cup G_2$ is given by $\boxed{G_1 \cup G_2 = (V_1 \cup V_2,\ E_1 \cup E_2)}$.

It is a graph whose vertex set is $V_1 \cup V_2$ & the edge set is $E_1 \cup E_2$.

* |||ly, the intersection of G_1 & G_2 is a graph whose vertex set is $V_1 \cap V_2$ & the edge set is $E_1 \cap E_2$ where $V_1 \cap V_2 \neq \phi$.

$$\boxed{G_1 \cap G_2 = (V_1 \cap V_2,\ E_1 \cap E_2)} \text{ if } V_1 \cap V_2 \neq \phi.$$

* $\boxed{G_1 \Delta G_2 = (V_1 \cup V_2,\ E_1 \Delta E_2)}$ is called the ring sum of G_1 & G_2.

$$E_1 \Delta E_2 = (E_1 \cup E_2) - (E_1 \cap E_2)$$

* Decomposition - we say that ~~two graphs G_1 & G_2~~ a graph G is decomposed into two subgraphs G_1 & G_2 if

$$G_1 \cup G_2 = G \quad \& \quad G_1 \cap G_2 = \text{Null graph.}$$

* Deletion - If v is a vertex in a graph G, then $G-v$ denotes the subgraph of G obtained by deleting v and all edges incident on v, from G. This subgraph, $G-v$ is called <u>vertex-deleted subgraph of G.</u>

* If e is an edge in a graph G, then $G-e$ denotes the subgraph of G obtained by deleting e, but not its end vertices, from G. This subgraph $G-e$ is called <u>edge deleted subgraph of G.</u>

* Given a graph G and a subgraph G_1 of G, the subgraph of G obtained by deleting all the edges from G that belong to G_1 is called <u>complement of G_1 in G</u> & is denoted by $G-G_1$ or $\overline{G_1}$.

* If G is a simple graph of order n, then the complement of G in K_n, is called the <u>complement of G</u> : it is denoted by $\overline{G}$.