10.07.2025 (10)

Types of Relation

1. Reflective Relation

aRa for all $a \in N$ → সবগুলো উপাদানের pair থাকতে হবে।

$A = \{1, 2, 3\}$

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

2. Irreflexive Relations : সবগুলো উপাদান এর pair না থাকলে / যদি একটি pair থাকে তবে সেটি not irreflexive

$(a,a) \notin R$

3. Symmetric Relation

$(a,b), (b,a)$

aRb bRa for every element

Ex. $A = \{1,2,3\}$

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

4. Antisymmetric

aRb, bRa & $\boxed{a=b}$

$(2,2)$ $(1,1)$

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

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

5. Asymmetric Relation :

$(a,b) \notin (b,a)$ [(a,b) থাকলে (b,a) থাকবে না.

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

× $R_1 = \{(1,1), (1,2), (2,3), (1,3), (4,4)\}$

× $R_2 = \{(1,1), (1,2), (2,1), (2,2), (3,3), (4,4)\}$

✓ $R_3 = \{(1,3), (2,1)\}$

✓ $R_4 = \emptyset$ [ফাঁকা সেট Asymmetric)]

× $R_5 = A \times A$

(2,1) (1,3) = (2,3) ×

Not transitive

6. Transitive Relations :

(a,b) & (b,c) then there must be $\boxed{(a,c)}$

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

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

$(1,1)\ \ (1,2) \longrightarrow (1,2)$ আছে ,

$\downarrow\ \downarrow\ \ \ \downarrow\ \downarrow \qquad\qquad \downarrow\ \downarrow$

$a\ \ b\ \ \ \ b\ \ c \qquad\qquad\quad a\ \ c$

$(1,2),(2,3) \longrightarrow (2,3)$

$(2,3),(1,3) \longrightarrow \times$ [condition মানে নি)

$(1,3),(4,4) \longrightarrow \times$ [condition মানে নি)

$\times$

so, this is transitive Relation.

—o—

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

$R_1 = \{(1,1), (2,2), (2,3), (3,2), (4,2), (4,4)\}$

1. Relation R_1 is not Reflexive because it does not contains all order pairs of the form (a, a) for every element $a \in A$ ie, R_1 has only $(1,1)$ $(2,2)$ & $(4,4)$ not $(3,3)$

2. Relation R_1 is not irreflexive because ~~(3,3)~~ $(1,1)$ $(2,2)$ and $(4,4)$ is there in R_1.

3. Relation R_1 is not Symmetric because for $(4,2)$ there is not $(2,4)$.

4. Relation R_1 is not antisymmetric because for $(2,3)$ is here and $(3,2)$ is also here but $2 \neq 3$.

5. Relation R_1 is Not transitive because there $(2,2), (2,3)$ has $(2,3)$ $(3,2), (2,3) \rightarrow (3,3)$
$(2,3), (3,2)$ has $(2,2)$

$(4,4)$, $(4,2)$ has $(4,2)$

6. Relation R_1 is not an asymmetric ~~ref~~ relation because of $(1,1)$, $(2,2)$ & $(2,3)$, $(3,2)$ and $(4,4)$.

* problem solving : Determine whether relation R on the set of all real numbers is reflexive, symmetric, antisymmetric, and/or transitive, where, $(x,y) \in R$ if and only if

~~a)~~ $x+y=0$ b) $x-y$ is a ~~a~~ rational number.
c) $xy=0$
d) $x=1$ or $y=1$

a) $R = \{(x,y) \mid x+y=0\}$

1. Reflexive : $\forall a \in R \, ((a,a) \in R)$

Not reflexive. Only true for $(0,0)$

2. Symmetric

$\forall a \forall b \in R \, ((a,b) \in R \rightarrow (b,a) \in R)$

if $a+b=0$ then $b+a=0$

Therefore, R is symmetric.

3. Antisymmetric:

$\forall a \forall b \in R(((a,b) \in R \wedge (b,a) \in R) \rightarrow (a=b))$

So, Not antisymmetric

$1+(-1)=0$ and $-1+1=0$, but $-1 \neq 1$

4. Transitive,

$\forall a \forall b \forall c (((a,b) \in R \wedge (b,c) \in R) \rightarrow (a,c) \in R)$

Therefore, not transitive

$1+(-1)=0$ and $(-1)+1=0$

but $1+1 \neq 0$

(b) $R=\{(x,y) \mid x-y$ is a rational no.$\}$

(1) Reflexive,

$a-a=0$ is a rational number.

2. Symmetric: if $a-b$ is a rational number

then $b-a = -(a-b)$ is also a rational number.

3. Antisymmetric: Not antisymmetric

$3-2$ and $2-3$ are both rational number

but $3 \neq 2$

4. Transitive:

if $a-b$ is a rational number and $b-c$ is also a rational number, then ~~a-c~~ $a-c = (a-b)+(b-c)$ is also a rational number.

closure properties :

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① Reflexive বানানো

$R \cup \boxed{\Delta_A}$

✓ $\Delta_A = \{(a,a) : a \in A\}$

~~$R \cup R^{-1}$~~

② symmetric বানানো,

$\boxed{R \cup R^{-1}}$

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

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

reflexive :

$(R) = R \cup \Delta_A$

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

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

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

Symetric (A) !

$R \cup R^{-}$

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

transitive বানানো :

$R \circ R = R^2$

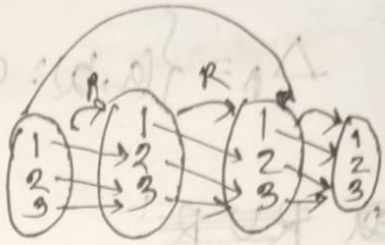
$R^2 \circ R = R^3$

$R^3 \circ R = R^4$

transitive $(R) = R \cup R^2 \cup R^3 \cup \ldots \cup R^4$

$A = \{1, 2, 3\}$

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



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

$(1,3), (2,3), (3,3)$

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

$(1,3)\ (2,3), (3,3)$

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

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

<u>Equivalence Relation :</u>

1. aRa
2. aRb then bRa
3. If aRb, bRc, then must aRc

$A = \{1, 2, 3\}$

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

Relation R is reflexive, symmetric and transitive

thats why Relation R is equivalence.

a) To each person on the earth assign the number which corresponds to his age

b) To each country in the world assign the latitude and lagitude of it's country

a) Sol^n:

$a \to 13$
$b \to 18$
$c \to 13$
$d \to 19$

$a \to 13$
$b \to 13$

so, it's not ~~not~~ onto function.

b) (onto function)

— o —

$$Q(a,b) = \begin{cases} 0 & \text{if } a<b \\ Q(a-b,b)+1 & \text{if } b \le a \end{cases}$$

$$Q(12,5) = Q(7,5)+1$$
$$= [Q(2,5)+1]+1$$
$$= [0+1]+1$$
$$= 2$$

Ackerman :

$A(m,n)$

a) if $m=0$, then $A(m,n)=n+1$

b) if $m\neq 0$ but $n=0$, then $A(m,n)=A(m-1,1)$

c) if $m\neq 0$ and $n\neq 0$, then $A(m,n)=A(m-1,A(m,n-1))$

$A(1,3)$

$A(1,3)=A(0,A(1,2))$

$= \cancel{A(3)} \Rightarrow A(1,2)=A(0,A(1,1))$

$A(1,1)=A(0,\underline{A(1,0)}) \rightarrow A(0,2)$

$A(1,0)=A(0,1)$

$=1+1=2$

$A(1,1)=A(0,2)=2+1=3$

$A(1,2)=A(0,3)=3+1=4$

$A(1,3)=A(0,4)=4+1=5$

$\therefore \boxed{A(1,3)=5}$

(Ans)

PROPOSITION

Single proposition :-

Compound proposition :- Many proposition are composite, that is composed of subpropositions and varius connectives discussed subsequently. Such composite ~~called~~ proposition called

Basic logical operation :-

conjuction $(p \wedge q) \rightarrow$ AND

~~p~~

$p \wedge q$

p = Roses are red

q = violets are blue

$p \wedge q$ = Roses are red and violets are blue.

p	q	$p \wedge q$
T	T	T
T	F	F
F	~~F~~ T	F
F	F	F

disjunction: (OR)

$\boxed{p \vee q}$

Paris is in France or 2+2=4

$p \qquad \vee \qquad q$

$p \vee q$

p	q	$p \vee q$
T	T	T
T	F	T
F	T	T
F	F	F

Negation: $\neg p$

p	q	$\neg q$	$(p \wedge \neg q)$	$\neg(p \wedge \neg q)$
T	T	F	F	T
T	F	T	T	F
F	T	F	F	T
F	F	T	F	T

p	q	$\neg$	(p	$\wedge$	$\neg$	q)
T	T	T	T	F	F	T
T	F	F	T	T	T	F
F	T	T	F	F	F	T
F	F	T	F	F	T	F
			①	③	②	①

if All output true → totology.

if All " false → contraduction.

$\boxed{p \vee \neg p}$

p	$\neg$p	p $\vee \neg$p → totology	p $\wedge \neg$p → contradiction
T	F	T	F
F	T	T	F

p $\vee \neg$(p $\wedge$ q)

p	q	p $\wedge$ q	~~p∨~~ $\neg$(p $\wedge$ q)	p $\vee \neg$(p $\wedge$ q)
T	T	T	F	T
T	F	F	T	T
F	T	F	T	T
F	T	F	T	T

$\neg(p \wedge q) = \neg p \vee \neg q$

p	q	$(p \wedge q)$	$\neg(p \wedge q)$
T	T	T	F
T	F	F	T
F	T	F	T
F	F	F	T

p	q	$\neg p$	$\neg q$	$\neg p \vee \neg q$
T	T	F	F	F
F	T	T	F	T
T	F	F	T	T
F	F	T	T	T

1. It is not the case that Roses are red and violets are blue
   ($\neg$ ... p ... $\wedge$ ... q)

2. Roses are not red or voilets are not blue
   ($\neg p$ ... $\vee$ ... $\neg q$)

#

$p \longrightarrow q$ = if p then q [p implise q]

$p \longleftrightarrow q$ = (if and only if) q

p	q	$p \longrightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

→ if p true & q false the $\boxed{p \to q}$ False

$\boxed{p \longleftrightarrow q}$

T	T	$\longrightarrow$	T
F	T	$\longrightarrow$	F
T	F	$\longrightarrow$	F
F	F	$\longrightarrow$	T

$$\boxed{\boxed{p \longrightarrow q} \equiv \neg p \vee q}$$

p	q	$\neg p$	$\neg p \vee q$
T	T	F	T
F	T	T	T
T	F	F	F
F	F	T	T

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Argument :

$$\underbrace{P_1, P_2, P_3, \ldots P_n}_{\text{premises}} \;\; \xrightarrow{\text{Argument sign}} \vdash \;\; \underbrace{Q}_{\text{conclusion}}$$

$$\underbrace{(P_1 \wedge P_2 \wedge P_3 \wedge \ldots \ldots \wedge P_n) \longrightarrow Q}_{\text{toutology}}$$

$p \longrightarrow q \rightarrow ①$

$q \longrightarrow r \rightarrow ②$

$\overline{p \longrightarrow r \rightarrow Ⓕ}$

$$p \rightarrow q, \; q \rightarrow r \vdash p \rightarrow r$$

$$\underbrace{[(p \rightarrow q) \wedge (q \rightarrow r)] \longrightarrow (p \rightarrow r)}_{\text{toutology}}$$

p	q	r	$(p \rightarrow q)$	$(q \rightarrow r)$	$(p \rightarrow q) \wedge (q \rightarrow r)$	$(p \rightarrow r)$
T	F	T	T	T	T	T
T	F	F	F	T	F	F
F	T	T	T	T	T	T
F	F	F	T	T	T	T

P	q	r	(p → q) ∧ (q → r)
T	T	T	
T	T	F	
T	F	T	
T	F	F	
F	T	T	
F	T	F	
F	F	T	
F	F	F	

$\boxed{(p \to q) \wedge (q \to r) \longrightarrow (p \to r)}$ H.W

S1: If a man is ~~unhappy~~ Bechlor, he is unhappy

$\underbrace{\text{a man is Bechlor}}_{p}$, $\underbrace{\text{he is unhappy}}_{q}$

S2: If a man is unhappy, he dies young.

$\underbrace{\text{man is unhappy}}_{q}$, $\underbrace{\text{dies young}}_{r}$

S3: Bechloor dies young.

$p \to r$

H.W

$$\frac{\begin{array}{c} p \to q \\ q \to r \end{array}}{p \to r} \Longrightarrow [(p \to q) \wedge (q \to r)] \longrightarrow (p \to r)$$

-Next

10-8 2023

S1 → If 7 is less than 4, then 7 is not a prime number.

p q $\neg q$

S2 → 7 is not less than 4 $-p$

$p \to q \to$

S3: 7 is a prime number q

$\boxed{(p \to \neg q) \to \neg q}$

$-F \vee \neg q$

p	q	$\neg p$	$p \to q$	$(p \to q) \wedge (\neg p)$	$\neg q$	$(p \to q) \wedge (\neg p) \to \neg q$
T	T	F	F	F	F	T
T	F	F	F	F	T	T
F	T	T	T	T	F	F
F	F	T	F	F	T	T

$-p \vee -(\neg q)$

p	q	$\neg p$	$\neg q$	$(p \to -q)$	$\{(p \to -q) \wedge p\}$	$\{(p \to \neg q) \wedge p\} \to q$
T	T	F	F	F	F	T
T	F	F	T	T	T	F
F	T	T	F	T	F	T
F	F	T	T	T	F	F

Propositional function:

$P(a) \rightarrow$ True / false for all $\boxed{a \in A}$

T_P F $\{x : P(x)\}$

$\forall_x (P(x) \rightarrow$ Universal quantifier

$\hookrightarrow$ True for all element

$(\forall x \in N)(x+4>3) \rightarrow$ True

$n = 1, 2, 3 \ldots$

$(\forall x \in N)(x+4<3) \rightarrow$ False

Existential quantifier:

$\exists_x P(x) \rightarrow$ True for any element / value at least one.

$(\exists_n \in N)(x+4<7) \rightarrow$ True

$n = 1, 2 \rightarrow$ True

$n = 3, 4 \ldots \rightarrow$ false

$(\exists_n \in N)(x+8<7) \rightarrow$ false

Negation of those :-

$\neg(\forall_x \in M)(\underbrace{x \text{ is male}}_{p(x)})$

All math majors are male

It is not the case [ ]

There exist at least one math major who is female

$(\exists_x \in M)(\underbrace{x \text{ is not}}_{\neg p(x)} \text{ male})$

$\neg[\forall x \in A)\ p(x)] = [\exists_x \in A) \neg p(x)$

\# ~~for~~ all positive integers n, we have $\underbrace{n+2 > 8}_{p(x)}$

$\neg[(\forall_n \in N)\ p(x)]$

$(\exists_n \in N) \neg p(x)$

There exist ~~at least~~ ~~one~~ at least one n,

There exists a positive integer n. Such that

$n+2 \not> 8$

$\neg[(\exists_x \in A)(P(x))] = (\forall_x \in A) \neg P(x)$

$P(x,y) \quad x+y=10$

$\forall_x \exists_y, P(x,y)$

For All x there exist a y, such that $x+y=10$

$B=\{1,2,\ldots,9\}$

this statement true.

$\exists_y \forall_x$ ~~B~~, $P(x,y)$

there exist a y such that for all x, we have $x+y=10$

false

$\rightarrow [\forall_x \exists_y, P(x,y)]$

$= \exists_x, \forall_y \longrightarrow P(x,y)$

Que. $U = \{1, 2, 3\}$

a) $\exists x \; \forall y \; , \; x^2 < y+1$

for $x = 1$,

$$T \begin{cases} 1^2 < 1+1 \\ 1^2 < 1+2 \\ 1^2 < 1+3 \end{cases}$$

So condition is true.

b) $\forall x \; \exists y \quad x^2 + y^2 < 12$

$$T \begin{cases} 1^2 + 1^2 < 12 \\ 1^2 + 2^2 < 12 \\ 1^2 + 3^2 < 12 \end{cases}$$

So condition true.

c) $\forall x \; \forall y \; \boxed{, \; x^2 + y^2 < 12}$

false

—o—

NORMAL FORMS

$$(\vee\ \vee) \wedge (\vee\ \vee) \wedge (\vee\ \vee)$$

$\downarrow$

Bracket এর ভেতরে ($\wedge$) থাকবে না।

CNF (conjuctive normal form)

$$(p \wedge q) \vee (\neg p \wedge q \wedge r)$$

$$\hookrightarrow (\vee) \wedge (\vee) \wedge (\vee)$$

$$= [p \vee (\neg p \wedge q \wedge r)] \wedge [q \vee (\neg p \wedge q \wedge r)]$$

$$= [\underbrace{(p \vee \neg p)}_{T} \wedge (p \vee q) \wedge (p \wedge r)] \wedge [(q \vee \neg p) \wedge (q \vee q) \wedge (q \vee r)]$$

$$= (p \vee q) \wedge (p \vee r) \wedge (q \vee \neg p) \wedge q \wedge (q \vee r)$$

$$(A \cup B)^c = A^c \cap B^c$$

$$\boxed{\neg(p \vee q) = \neg p \wedge \neg q}$$

DNF → Disjunctive Normal form.

[Normal form বাদ]

$(\quad) \vee (\quad) \vee (\quad)$

Ex– $(\neg p \rightarrow p) \wedge (p \leftrightarrow q)$ DNF?

$p \leftrightarrow q = (p \rightarrow q) \wedge (q \rightarrow p)$

$= (\neg p \vee q) \wedge (\neg q \vee p)$

parmutation & combination

parmutation :

a, b, c, d

abcd, acbd, adcb . . .

abc, acb, acd . . .

ab, bc . . .

a . . .

$$P(n, r) = {}^{n}P_{r} = \frac{n!}{(n-r)!}$$

$$P(6,3) = \frac{6!}{(6-3)!} = 120$$

Repitation থাকলে,

RADAR

RRAAD RRAAD

$$P(n, r) = \frac{5!}{2!\,2!} = \frac{5 \times \cancel{4}^{2} \times 3 \times \cancel{2!}}{2 \times 1 \times \cancel{2!}} = 30$$

(Ans)

Combination

a, b, c, d

Combination

abc	3! = 6
acd	3! = 6
bcd	6
abd	6

$$^{n}C_{r} = \frac{n!}{r!(n-r)!}$$

Suppose repetative are not permitted.

a) How many three digit numbers ~~are~~ can be form the six digit 2, 3, 9, 5, 6, 7

$\boxed{6}$ $\boxed{5}$ $\boxed{4}$ =

if, 0, 3, 9, 5, 6, 7

$\boxed{5}$ $\boxed{5}$ $\boxed{4}$

0 not allowed at first

b) How many of three are less then 400?

$\boxed{2}$ $\boxed{5}$ $\boxed{4}$ =

greater then 400 $\boxed{4}$ $\boxed{5}$ $\boxed{4}$ =

e) How many of three are even = ?

$\boxed{5}$ $\boxed{4}$ $\boxed{2}$ =

odd

$\boxed{5}$ $\boxed{4}$ $\boxed{4}$ =

— o —

Word Arrange :

MISSISSIPPI [ ]

$$= \frac{11!}{4!\,4!\,2!}$$

$$= \frac{11\times10\times9\times8\times7\times6\times5\times4!}{4!\,4!\,2!} \Rightarrow 11\times10\times9\times7 \Rightarrow \boxed{110\times63}$$

$= \boxed{34650}$

If P is assum single,

$$\frac{10!}{4!\,4!} \quad [PP \rightarrow P]$$

4 S must ~~be~~ not be separated

$$\frac{8!}{4!\,2!} \quad [SSSS \rightarrow S]$$

A bag contain six white marbles and five red marbel. Find the number of ways four marbles can be drawn the bag if a) they can be any color,

b) two must be white and two red

c) they must all be of the same color.

a) $^{11}C_4 = \binom{11}{4} \rightarrow$ combination,

$= \frac{11 \cdot 10 \cdot 9 \cdot 8}{4 \cdot 3 \cdot 2 \cdot 1}$

$= 330$ way

b) $\binom{6}{2}\binom{5}{2} = \frac{6 \cdot 5}{1 \cdot 2} \cdot \frac{5 \cdot 4}{1 \cdot 2} = 150$ way

c) $\binom{6}{4} + \binom{5}{4} = 15 + 5 = 20$ way

Q→ out of 12 employee a group of four trainers is to be sent for "Software testing QA' training of one month

a) How many ways can four empoyee be selected? $\longrightarrow {}^{12}C_4 = \frac{12\times11\times10\times9}{4\times3\times2\times1}$

b) What if ~~four~~ there are two empolyee refuse to go together for training?

(b)

i) if two are refuse, then,

${}^{10}C_4$

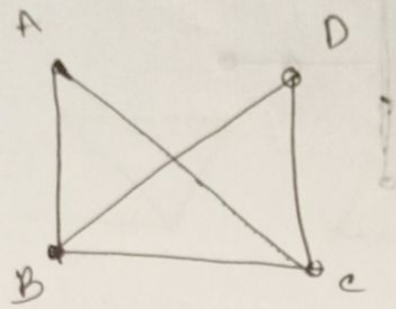
ii) ${}^{10}C_3$ if A refuse B go

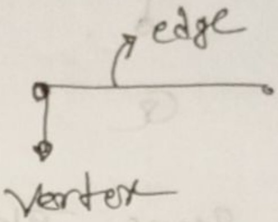
iii) ${}^{10}C_3$ if B refuse A go

So, total way,

${}^{10}C_4 + {}^{10}C_3 + {}^{10}C_3$

Graph

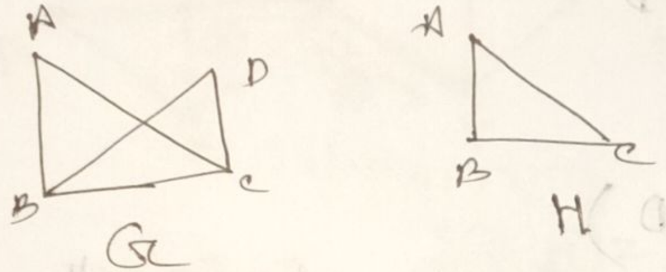




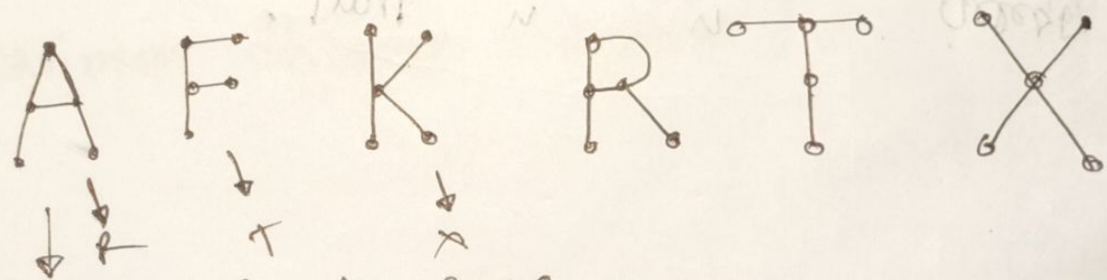
Degree of $A = 2$
Degree of $B = 3$

finite graph:

Subgraph:

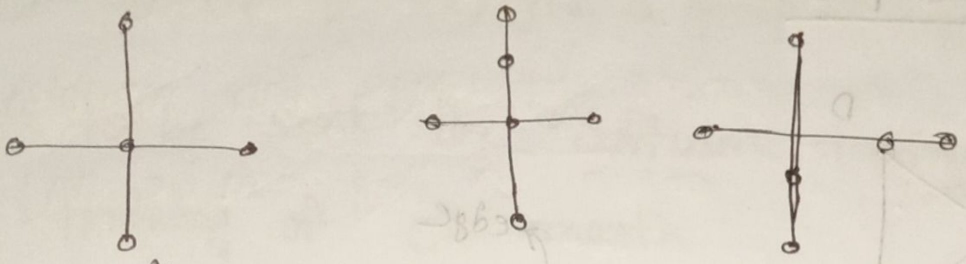


Isomorphic Graph:



vertex & edge same

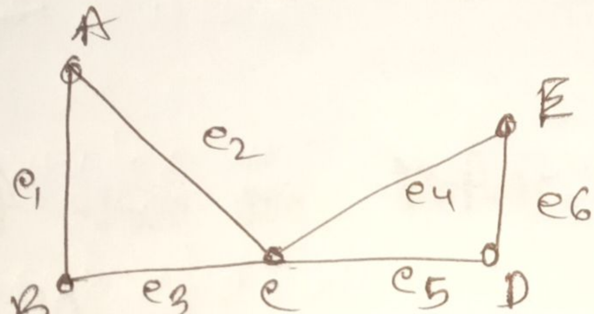
Degree সমান হবে & (1-1) corresponded



Base graph   G   H

* Base graph same হলে homomorphic Graph

Paths & connectivity :



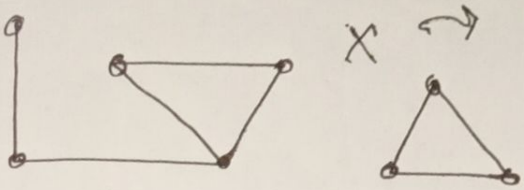
$A \to D$

$(A, e_1, B, e_3, C, e_5, D)$

vertex একবার traverse করলে simple path

edge একবার " " trail.

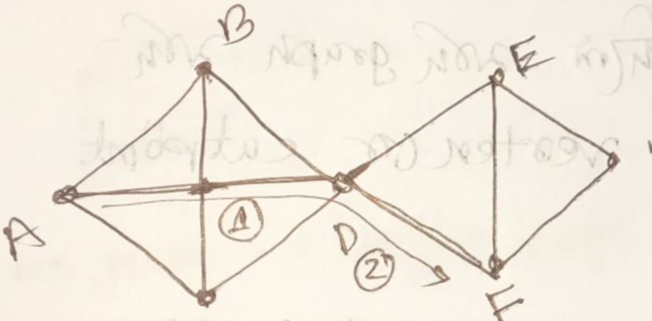
Connectivity :



Not connected / disconnected

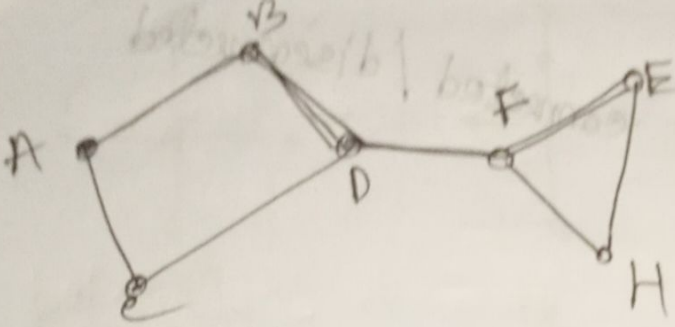
~~Distance and diagram~~: Diameter :

→ একটি vertex থেকে আরেকটি vertex এ যাওয়ার Shortest path called distance.



$d(A,F) = 2$ $d(A,H) = 3$

[Maximum distance = Diameter]



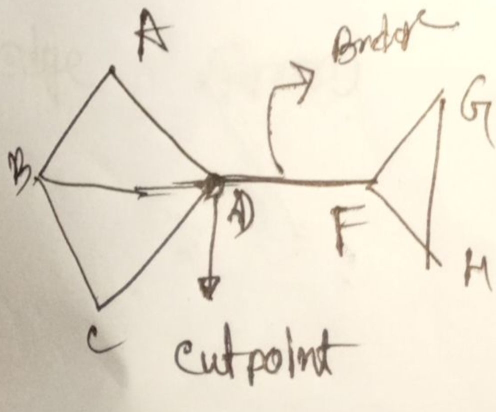
$[d(A,H) = 4]$

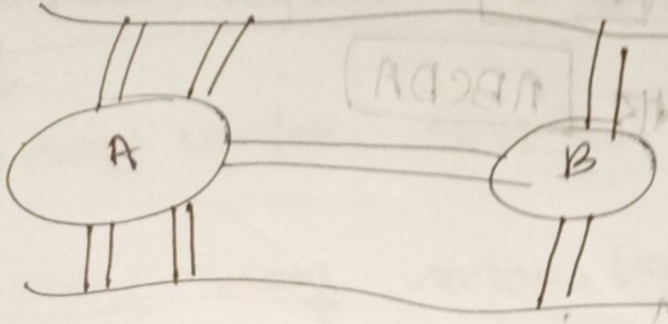
So, diameter $= 4$

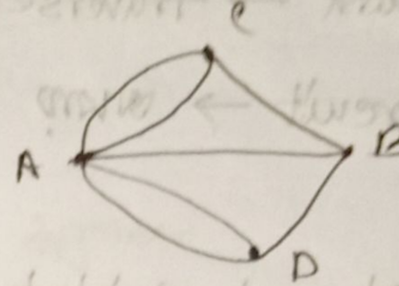
Bridge & Cutpoint :

কোনো vertex কে বাদ দিলে যদি graph যদি Disconnected হলে সেই vertex কে cutpoint বলে।

যদি edge কেটে দিলে Disconnected হয় তখন সেইটাকে Bridge বলে

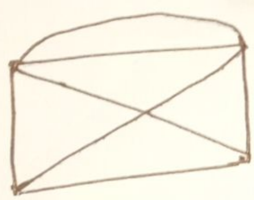




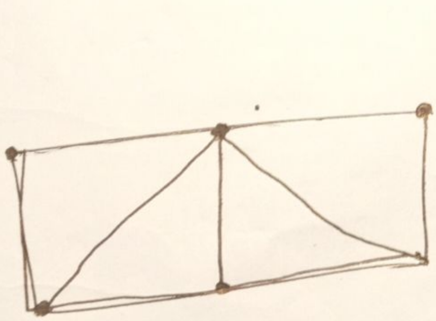


A finite connected graph is Eulerian if and only if each vertex has even degree.

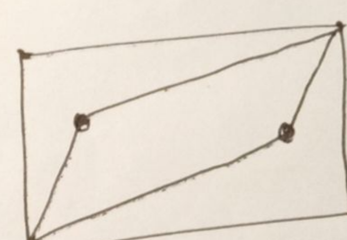
$\boxed{\text{traversable} = \text{odd two degree}}$



- Eulerian graph → সবগুলো edge কে একবার traverse করবে।
- Hamiltonian → সবগুলো vertex কে একবার 〃 〃



a) Hamilton & non-Eulerian.



b) Eulerian and non-Hamilton

Hamilton : if $n \geq 3$ and $n \leq$ degree(v) for every vertex.

path → traverse করতে হবে $\boxed{ABCD}$

circuit → আবার ফিরে আসবে $\boxed{ABCDA}$

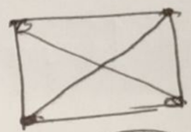
Labeled and Weighted graph :-

Complete, Reguler & Bipartite Graph :-

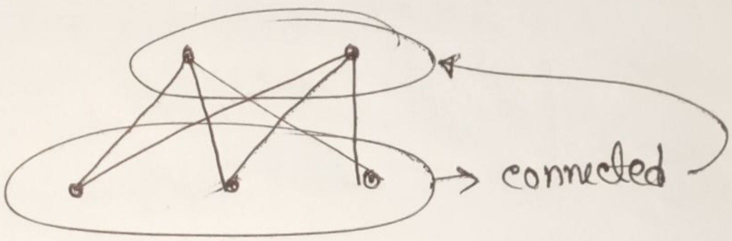
① every vertex connected in G

Reguler : every vertex has same degree

bipartite :-



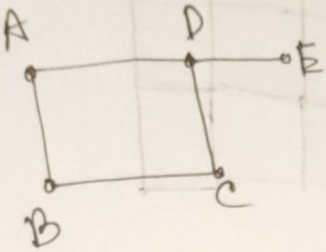
K_4



$K_{2,3}$

Graphs representation

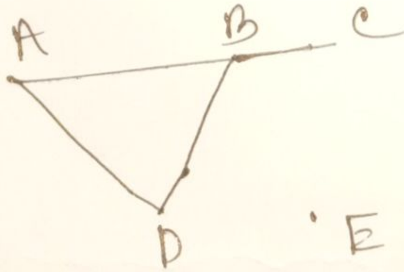
11.09.2025



$$a_{ij} = \begin{cases} 1 & \text{if } v_i \text{ } \cancel{\text{vertex}} \text{ adjcent } v_j \\ 0 & \text{otherwise.} \end{cases}$$

	A	B	C	D	E
A	0	1	0	1	0
B	1	0	1	0	0
C	0	1	0	1	0
D	1	0	1	0	1
E	0	0	0	1	0

Link list representation

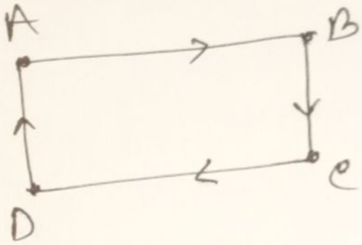


vertex	adj. list
A	B, D
B	A, ~~B~~ C, D
C	B
D	A, E
E	0

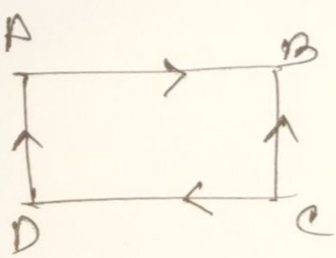
START

	1	2	3	4	5	6	7	8
Vertex	A	B	C	D	E			
Next V	1	2	3	4	5			
PTR								

Strongly connected graph



Unilateraly



~~Wek~~ weakly