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GATE

Computer Science

Ravindrababu Ravula GATE CSE
Hand Written Notes

-: SUBJECT :-
Database Management

Subject: DBMS (Database management system)

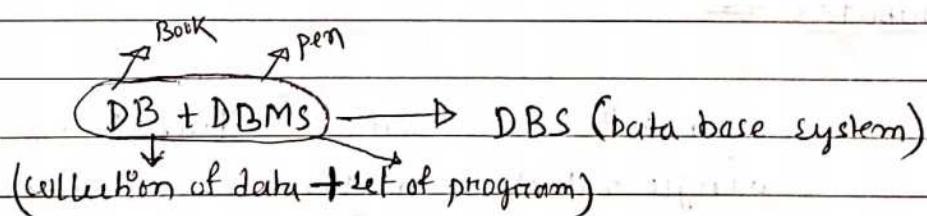
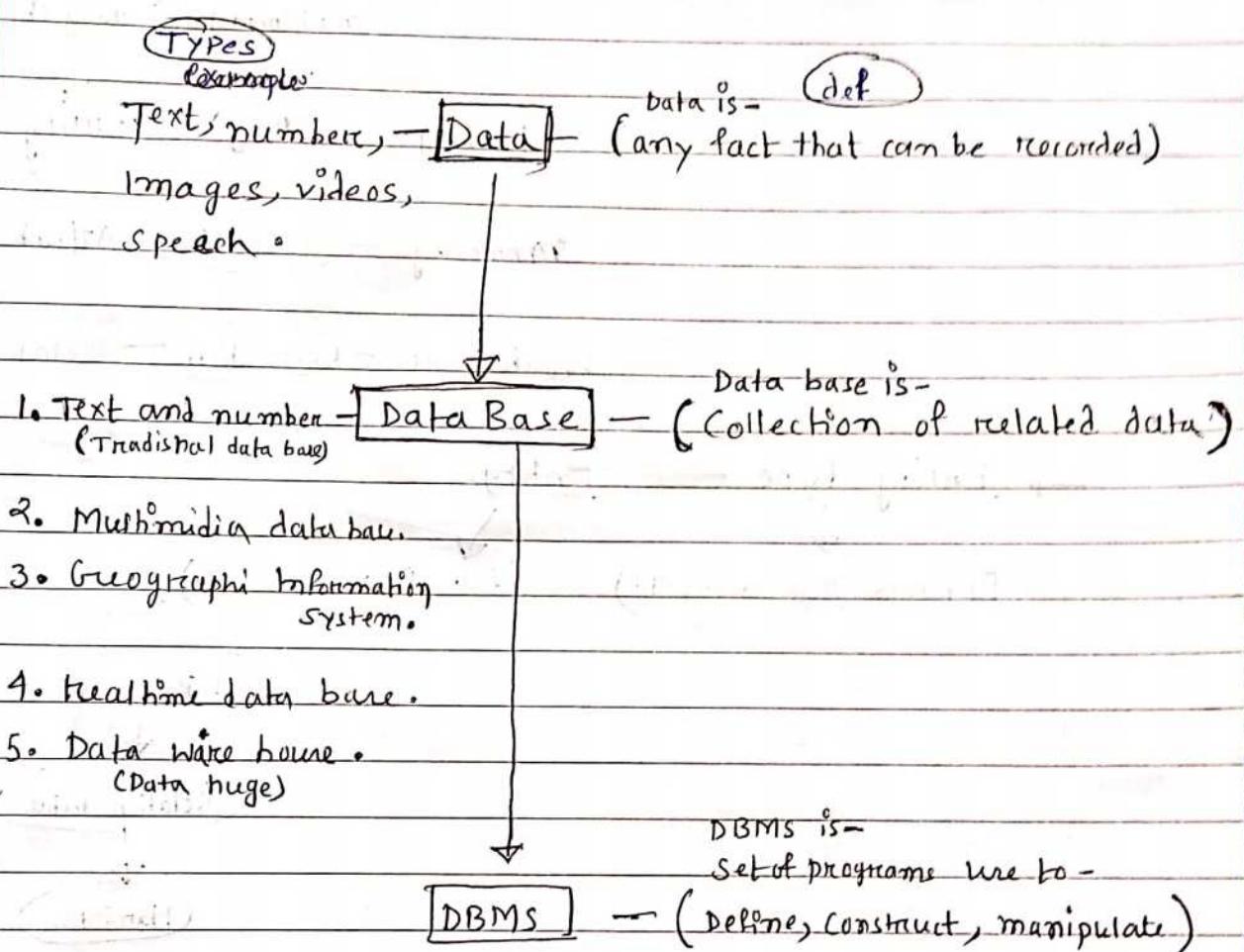


Serial Number	Date	Title	Page Number	Teacher's Sign/Remarks
✓ 1.		ER Model. - 1		
✓ 2.		Relational Database Model. - 2		
✓ 3.		Conversion of ER model to Relational model. - 3		
✓ 4.		Normalization. - 4		
✓ 5.		Relational Algebra. - 5		
✓ 6.		SQL. - 6		
✓ 7.		Transaction management and concurrency control. - 7		
✓ 8.		File Structure. - 8		

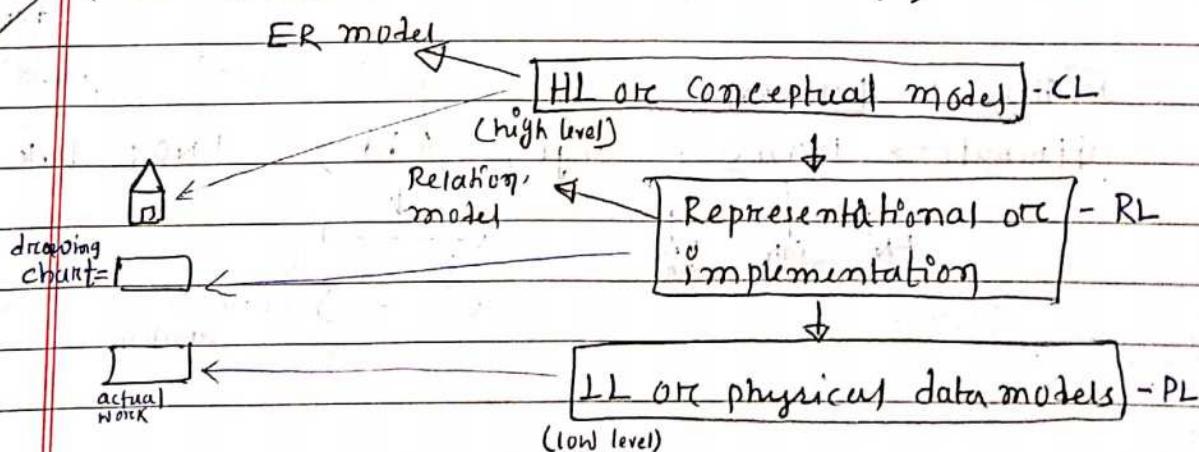
ER-Model

Page No :
Date :

Introduction to DBMS :

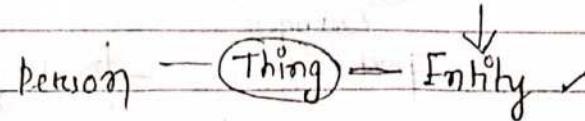


Models in DBMS : (Data Base design)



- Introduction to ER model = Entity-relationship model.

In ER-model - 3 thing should know

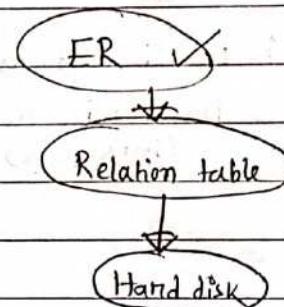


Name, age — Properties — Attributes ✓

works for — association — Relationship ✓

→ Entity type — Entity

PERSON (Age, Name, add) — (26, Rakesh, ...)



- Attributes =

Composite vs simple attribute.

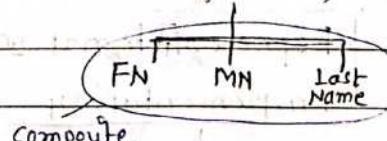
single valued vs multivalued attribute.

stored vs derived attribute.

Complex attribute → (Composite + Multivalued).

Entity → Person.

Attribute → Name,



single valued

multivalued

multivalued

Age, Add,

↓

P.NO;

Date of Birth,

(---)

(---)

)

complex
attribute.

Relationships =

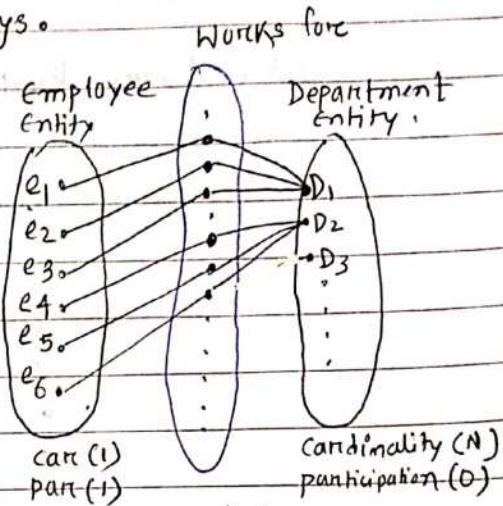
→ association b/w entitys.

Example - 1 (1 to many)

Requirement Analysis: Every employee (RA)

Works for a Department, and a dep can have many employee.

New dep need not have any employee.

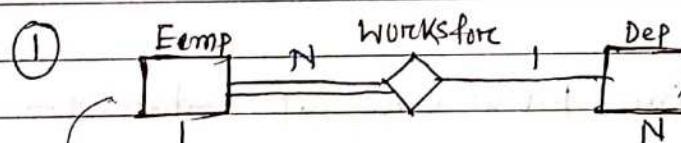


Structural constraint } cardinality ratio: Max relationship entity can participate.

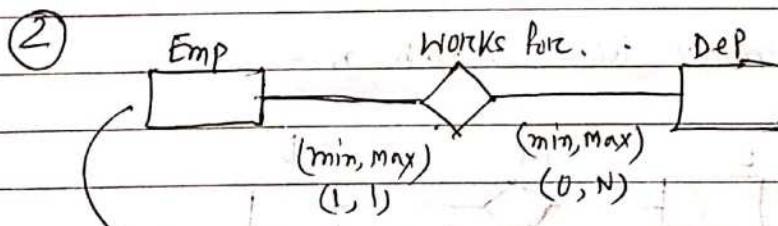
participation or existence: } min relationship entity can participate.

Entity represented by -

Relationship n -



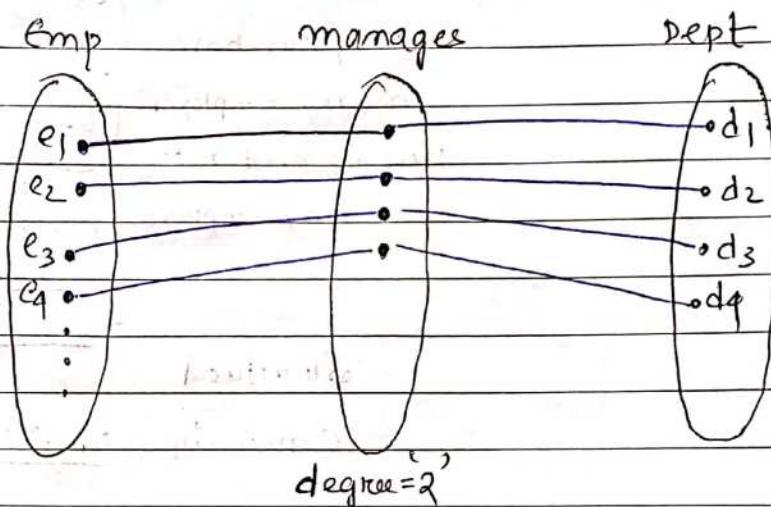
→ (Cardinality ratio / singe line / Doubleline)
representation of ER Diagram.



→ (min max representation of ER Diagram)
most info represent by

example - 2 (1 to 1)

RA : Every Dept should have a manager and only one employee manages a dept and one employee can manage only one dept.



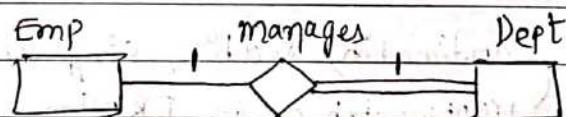
cardinality: 1

1

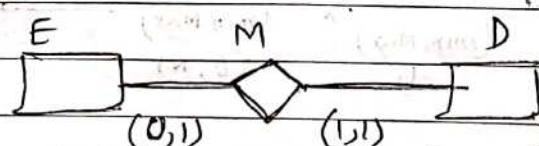
participation: 0 (P)

1 (Total)

① single line / Double line Representation -

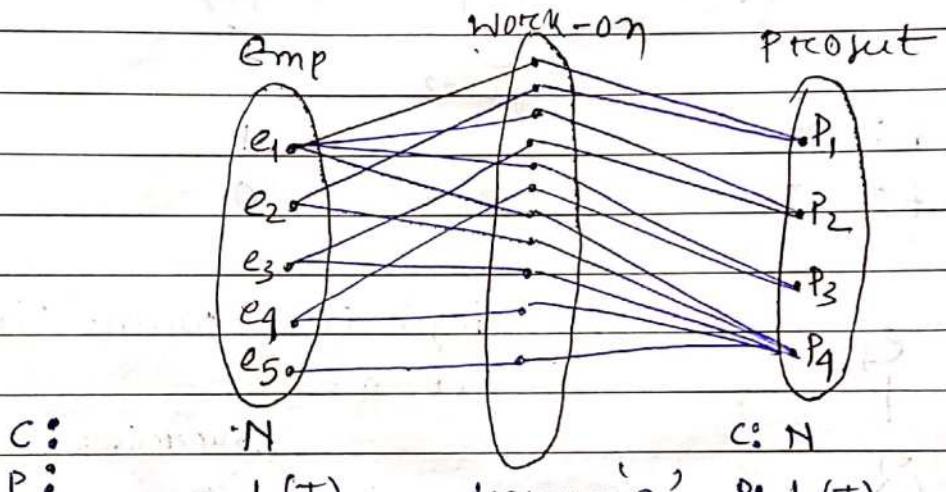


② min max representation -



Example-3] (many to many)

RA: Every employee ^{is} suppose to work atleast on one project and he can work many project. Similarly a project have can have many employees and every project is suppose to have one employee.



C:

P:

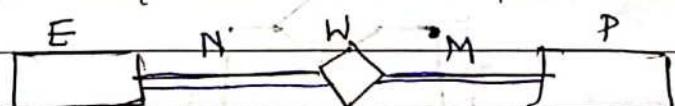
$$P_1 = e_1 e_2$$

$$P_2 = \text{obj} e_1 e_3.$$

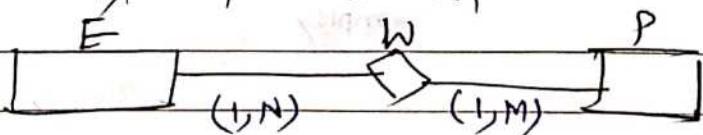
$$P_3 = e_1 e_4$$

$$P_4 = e_1 \ e_2 \ e_3 \ e_4 \ e_5$$

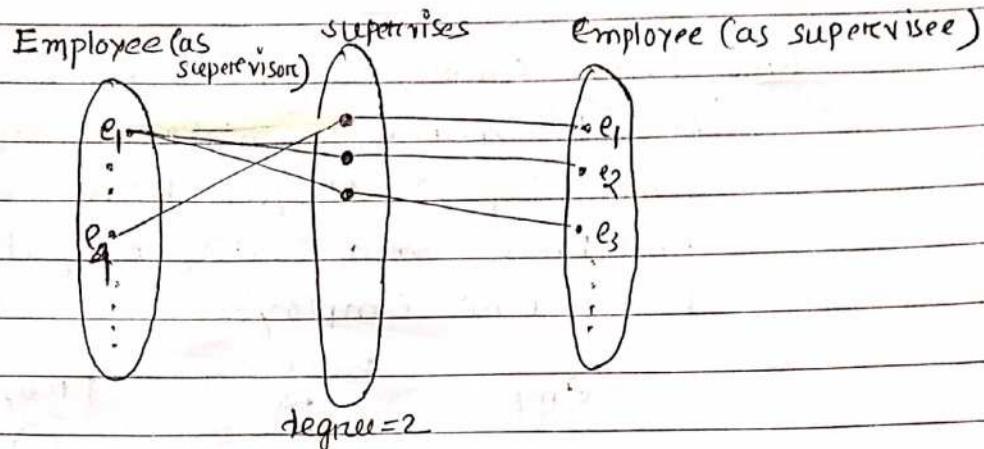
① single line / double line representation →



② Min Max representation -



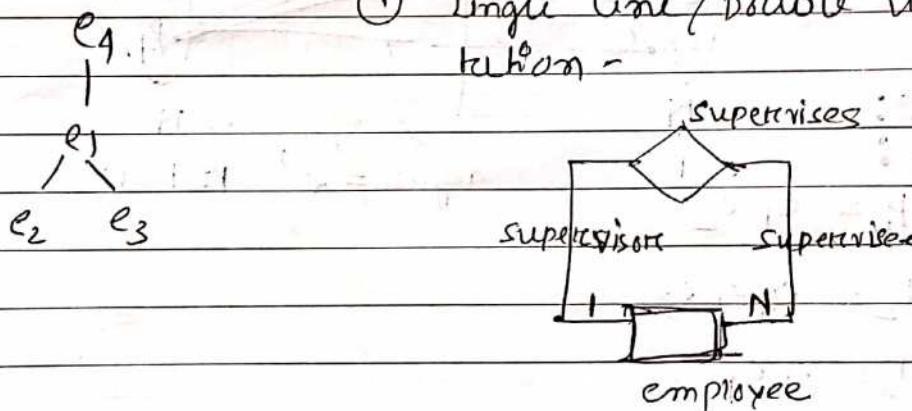
example - 4 (Recursive relationship)



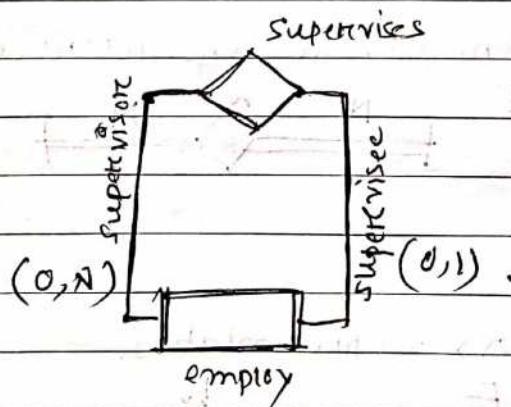
cardd : N

part : O

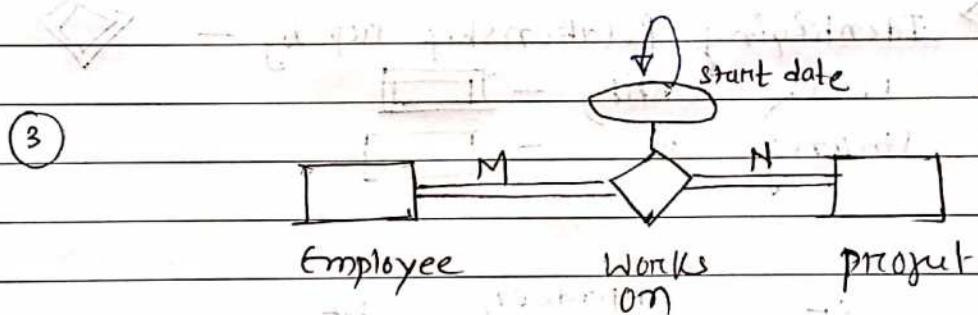
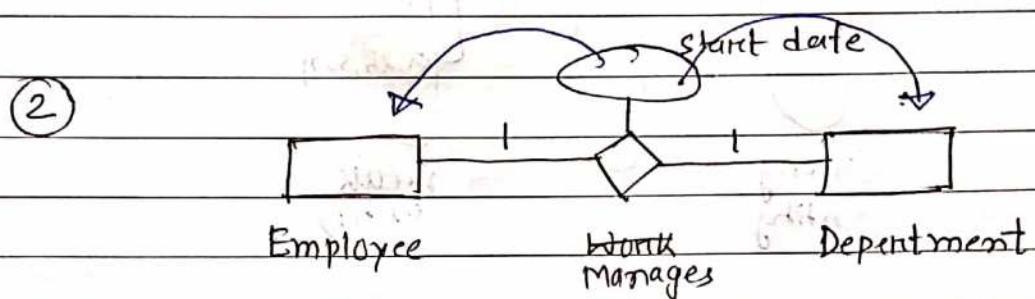
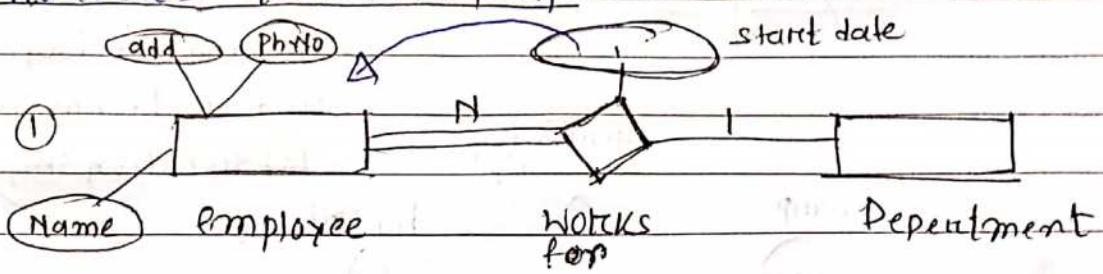
① Single line / Double line representation -



② Min Max representation of ER diagram -



- Attributes to relationships =



→ In this case Attribute can't shift any side, it will associate with relationship.

- Weak entity =

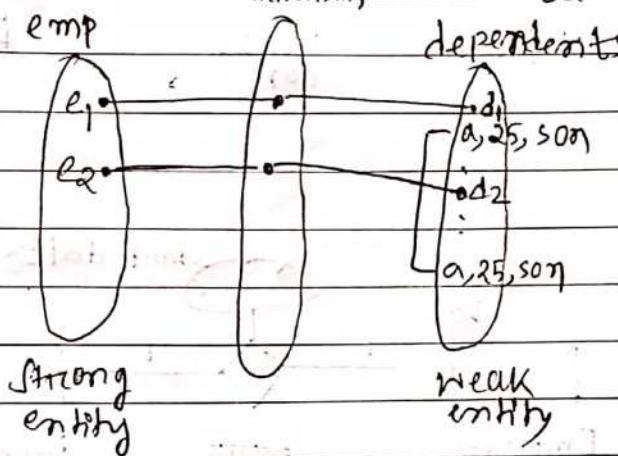
→ Whenever any entity having key attribute then such entity called weak entity.

→ The entity having key attribute, then such entity called strong entity. (like, id no, phone.no, Reg.no).

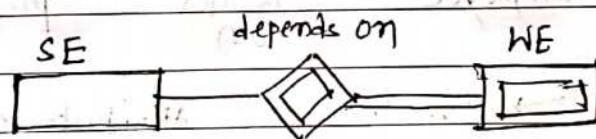
Identifying Relationship

(~~secondary~~ special relationship used to identifying weak entity)

Identifying relationship



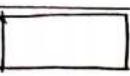
- Identifying Relationship rep by —
- Weak entity —
- Strong —

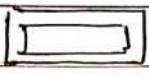


→ Weak entity participation ^{Pn} in identifying relationship is total.

→ And Every Total Participation doesn't say that the entity is weak.

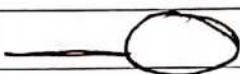
ER-diagram notations

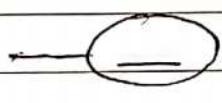
① Entity - 

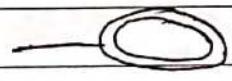
② Weak entity - 

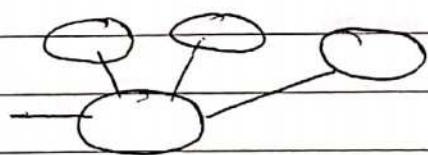
③ Relationship - 

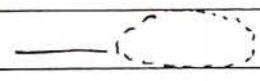
④ Identifying relationship - 

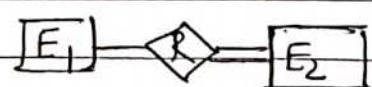
⑤ attribute - 

⑥ Key attribute - 

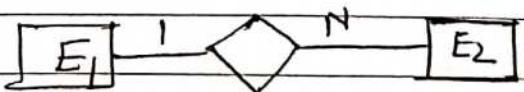
⑦ Multivalued attribute - 

⑧ composite attribute - 

⑨ derived attribute - 

⑩ Total participation of E₂ in R - 

⑪ cardinality ratio E₁:E₂=1:N -



Relational Database Model

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Date :

- Introduction to Relational model =

- Terminology of Relational database =

- ✓ relation — (table)
- ✓ tuple — (row)
- ✓ attributes — (columns)
- ✓ domain(D) — (Set of values) — (Eg. {1, 2, 3, 4})
- ✓ Relation Schema — $R(A_1, A_2, A_3, A_4)$
- ✓ degree of relation — (no. of attributes present in table)
- ✓ relation state —
- ✓ Intension — Some time relation schema is called intension.
- ✓ extension — Table itself.
- ✓ current relation state \rightarrow (elements present in table at any given point of time.)

Table name - R

	A ₁	A ₂	A ₃	A ₄
tuple				
Attribute				

$R(A_1, A_2, A_3, A_4)$ — Relation schema
 $\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$
 $D_1 \quad D_2 \quad D_3 \quad D_4$

$$n(R) \leq D_1 \times D_2 \times D_3 \times D_4$$

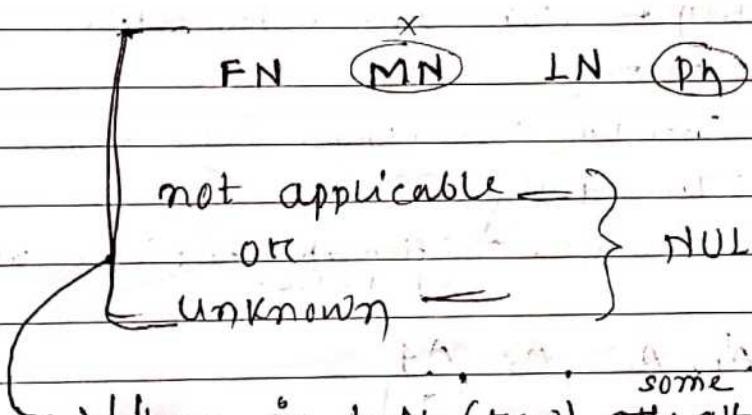
\rightarrow In relation model same two tuples can't place.

- Tuple, tuple value and NULL

domain

SN / SNO	Phno
a	201201
x	201201

→ two tuple (row) can't same.



→ When in tuple (row) some attribute not (middle name, phone.no) are not present, then in such case we use NULL.

- Relational constraints = (constraints on relational database schema)

4 - restriction (constraint) :

- (1) Domain constraints.
- (2) Key constraints. (also called uniqueness constraints)
- (3) Entity integrity constraints.
- (4) Referential integrity constraints.

① Domain Constraints = (entire schema of attribute should atomic)

Student	Name X	P.NO		
S.Nam	FN	MN	LN	
				() ()

atomic \rightarrow smallest individual unit.

\rightarrow every Domain should contain atomic value

\rightarrow composite attribute not allowed only simple attribute are allowed.

\rightarrow multi-valued attribute also not allowed.

② Key Constraints = (No. two tuple can't be same value)

				\rightarrow Super Key.
$t_1 \rightarrow$				
$t_2 \rightarrow$				

$t_1 \neq t_2$

$(S.\checkmark N.o, s.Nam, marks)$

Ravi 100

Super key \subseteq Attributes

(2) $\boxed{\text{key}}$: any minimal superkey is key.

Name	Age	D.No	Street NO

(1) $\boxed{\text{Super Key}}$: set of attributes able to pinout tuple uniquely

hence (Name, D.no, street no) \rightarrow Key.

\rightarrow In worst case superkey = key.

~~(Relationship b/w key and superkey)~~
 → any superset of a key is a superkey.

(S.NO, SName) - Superkey.

(S.NO, marks) - Superkey

(S.NO, SName, mark) - SKey.

→ In a table more than one minimap

→ (3) Candidate Keys : If we have more than one key for a table.

(4) Primary Key : first chosen candidate key.

→ Key may contain more than one attribute.

→ NULL value are not allowed in Primary Key.

(3) Entity integrity constraints =

→ here, primary key never allowed NULL value.

(4) Referential Entity integrity constraints =

→ Referential integrity can be define b/w two table or on the same table (in case of recursive relationship).

Project		Employee				Department	
P.NO		ENO	Ena	Dip.NO	PR.NO	Dip.NO	
1		1	.9	1	4	1	
2						2	
3						3	
4						9	

→ A table can contain more than one FK (Foreign Key).

• Actions upon constraint violations -

Operations of Data Base -

- (I) Insert. — (reject)
- (II) Delete.
- (III) Update. (modify)

Constraints -

- (I) Domain
- (II) Key
- (III) Entity Integrity
- (IV) Referential Integrity

(I) Insertion :

When any of the constraints fail while insert a key or tuple then Reject the insertion completely. (all constraints violated by insertion)

(II) Deletion :

- Domain constraints not violated by Deletion.
- Key constraints also not " " " "
- Entity Integrity " " " " " "
- (Only referential integrity violated by Deletion.)

Department			Employee		
	D.NO		E.no	E.no	D.NO
x	1		a	3	1(N)
	2				2

3 - Solutions to avoid refer. Integrity violations -

- Reject action. (Deletion not possible)
- Cascade (Deleted from both tables)
- Set NULL or some other value.

(III) Update :

→ combination of Delete and Insert.

(Delete a old tuple & put Insert new tuple)

Example - 1)

- Counting the number of super keys possible
- Counting the number of super keys possible

Example - 1)

given relation,

$$R(A_1, A_2, A_3, \dots, A_n)$$

candidate key = $\{A_1\}$
(minimal key)



$$R(A_1, A_2, A_3)$$

$$CK = A_1^{2 \times 2}$$

$$SK = \{A_1, A_1A_2, A_1A_3, A_1A_2A_3\}$$

$$= 2^{3-1} (2^{n-1})$$

$$R(A_1, A_2, A_3, \dots, A_n)$$

$$2 \times 2 \times 2 \times \dots \times 2$$

$$\text{no. of SK} = 2^{n-1}$$

Example - 2)give, $R(A_1, A_2, A_3, \dots, A_n)$

$$CK = A_1A_2$$

VS

$$R(A_1, A_2, A_3, A_4, \dots, A_n)$$

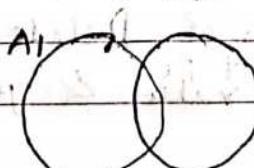
$$2 \times 2 \times 2 \times \dots \times 2$$

$$CK = A_1A_2 \rightarrow SK = 2^{n-2}$$

$$CK = A_1A_2A_3 \rightarrow SK = 2^{n-3}$$

VS

$$CK = \{A_1, A_2\} \rightarrow [SK(A_1) + SK(A_2) - SK(A_1 \cup A_2)]$$



$$= 2^{n-1} + 2^{n-1} - 2^{n-2}$$

else

Example - 3

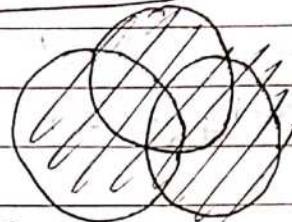
Given, $R(A_1, A_2, A_3, \dots, A_n)$

(i) $C_K = \{A_1, A_2, A_3\}$

$$\rightarrow SK(A_1) + SK(A_2) + SK(A_3) - SK(A_1 A_2 A_3)$$

$$\rightarrow 2^{n-1} + 2^{n-2} + 2^{n-3}$$

$$SK \rightarrow (2^{n-1} + 2^{n-2} + 2^{n-3}) \rightarrow$$



(ii) $X_C K = \{A_1, A_1 A_2\}$

(iii) $\rightarrow C_K = \{A_1 A_2, A_3 A_4\}$

$$\rightarrow SK(A_1 A_2) + SK(A_3 A_4) - SK(A_1 A_2 A_3 A_4)$$

$$\rightarrow 2^{n-2} + 2^{n-3} - 2^{n-4}$$

$$SK \rightarrow (2^{n-1} - 2^{n-4})$$

(iv) $C_K = \{A_1 A_2, A_1 A_3\}$

$$SK = SK(A_1 A_2) + SK(A_1 A_3) - SK(A_1 A_2 A_3)$$

$$= 2^{n-2} + 2^{n-3} - 2^{n-3}$$

$$SK = (2^{n-1} - 2^{n-3})$$

Example - 4)

$R(A_1, A_2, A_3, \dots, A_n)$

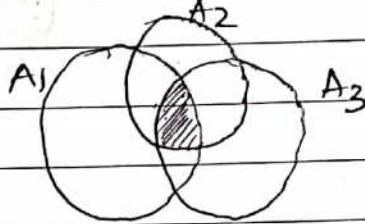
$CK = (A_1, A_2, A_3)$

$$\rightarrow SK = SK(A_1) + SK(A_2) + SK(A_3) \leftarrow SK(A_1 A_2) - SK(A_2 A_3) \\ - SK(A_1 A_3) + A_1 A_2 A_3$$

$$SK = 2^{n-1} + 2^{n-1} + 2^{n-1} - 2^{n-2} 2^{n-2} - 2^{n-2} + 2^{n-3}$$

$$= 2 \cdot 2^{n-1} - 2 \cdot 2^{n-2} + 2^{n-3}$$

$$= 2^n - 2^{n-1} + 2^{n-3}$$



NO of superkey possible

~~$R(A, B, C, D)$~~

~~$CK = (A, BC)$~~

$$SK = S(A) + S(BC) - S(ABC)$$

$$= 2^3 + 2^2 - 2^1 - 3$$

$$= 8 + 4 - 2$$

= 10 superkey possible.

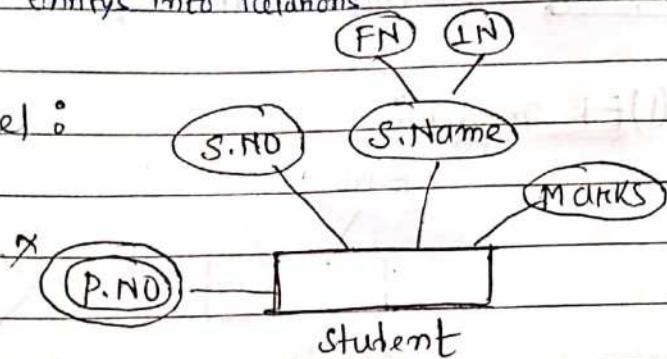
$(A, A, AB) - (A, B) R + (A, AB) - 3$

Conversion of ER model to Relation model

Fortune
 Page No : 19
 Date :

Step 1 "convert entity into relations"

ER model :



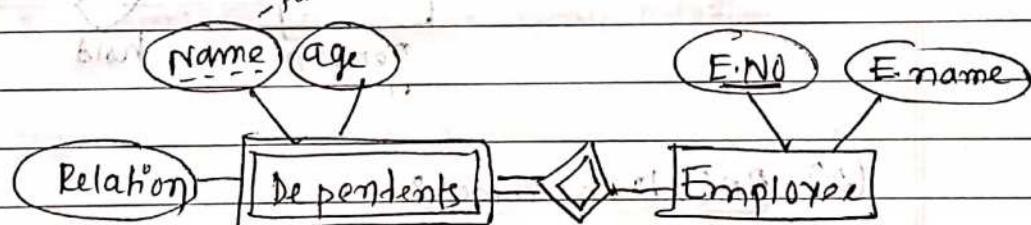
Relation model :

student

S.NO	Marks	FN	LN

Step 2 "convert weak entity into relation"

ER Model :



Relation model :

Dependent

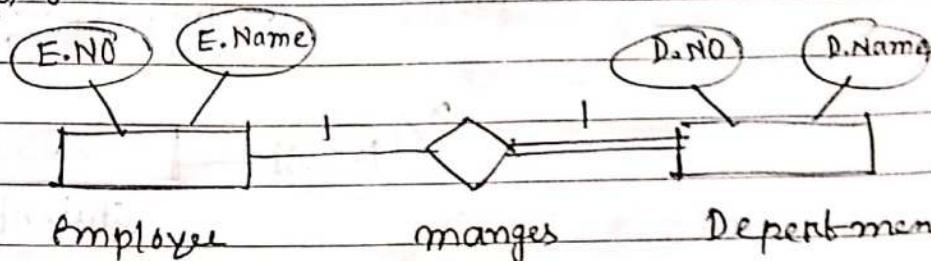
Employee

E.NO	Name	Age	Relation

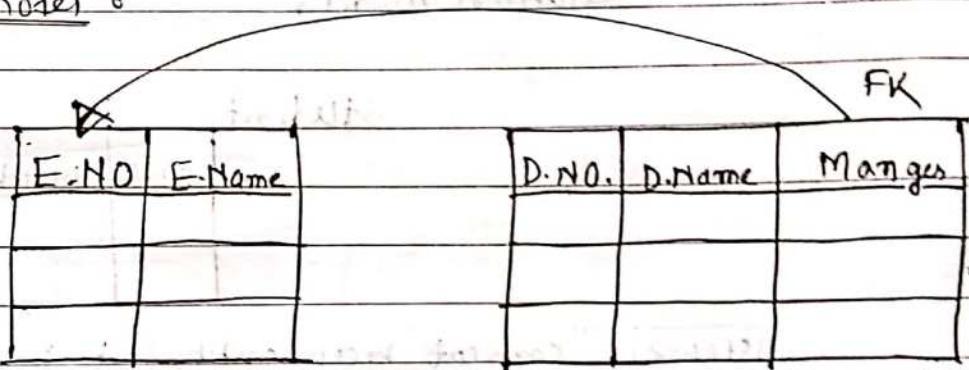
E.NO	E.name

Step-3 "Convert Relationship into Relation"

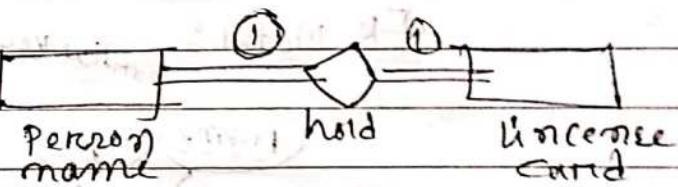
(1) ER model



(1) Relation model



(2) ER models



(2) Relation model

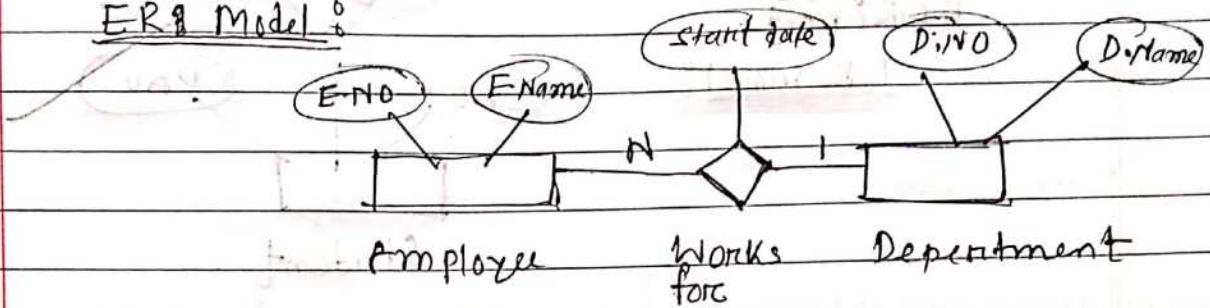
(both side participate totally)

Combine them in one relation
(table)

person name	licensee

Step - 4 "convert one to n relationship in table (relation)"

ER Model:

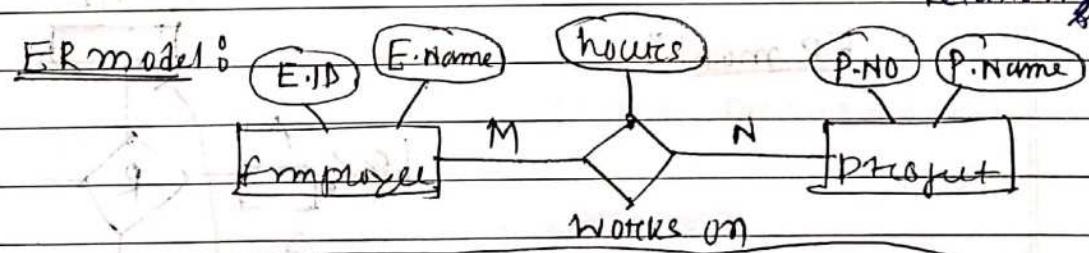


Relation model:

Employee			Department		
E-NO	F-Name	D-NO	SD	D-NO	D-Name

Step - 5 "convert many to many relationship into relation"

ER model:

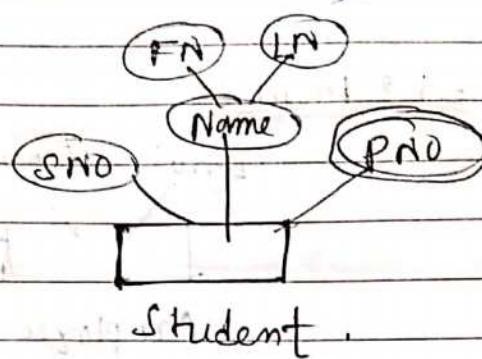


E-ID	E-Name	P-NO	P-Name	E-ID	P-NO
1	a	1	b	1	1
2		2	c	1	2
3		3	d	1	3
4		1	c	2	1

Step-6: "multivalued attributes"

ER model:

ER model:



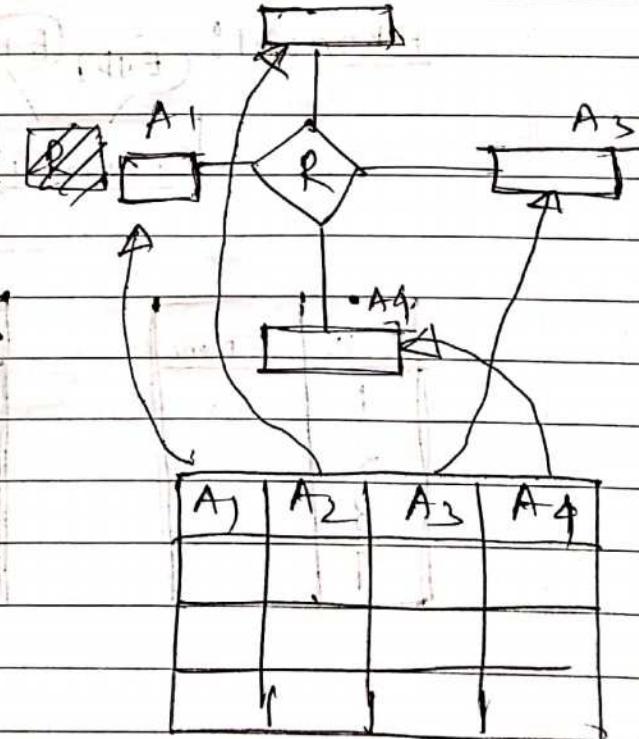
Relation model:

S.NO	FN	LN	P.NO
1			
2			
3			
4			
5			

ENO	P.NO
P1	P1
P2	P2
P3	P3
	:

Step-7: "n-many relation - Chip"

ER model:



Relationship:

Summary of ER to Relation Data Base Conversion:

ER MODEL

Entity type

1:1 or 1:N relationship type

M:N relationship type

n-many relationship type

Simple attribute

Composite attribute

Multivalued attribute

Value set

Key attribute

Relational model

"entity" relation

Foreign key (on relation)

relationship "relation" + 2 FKS

Relationship "relation" + m FKS

Attribute

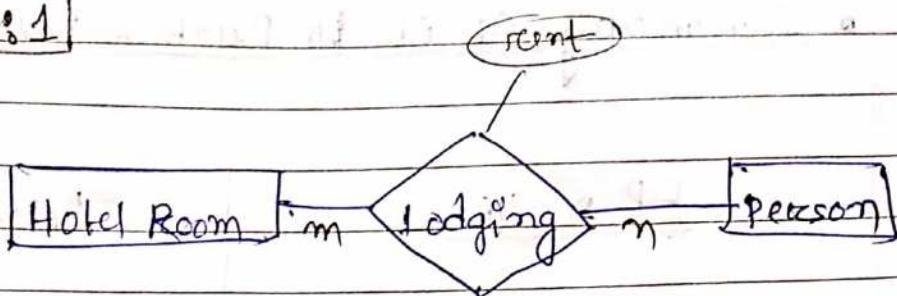
set of simple component attribute.

Relation (table) and Foreign key.

Domain

Primary Key

g' 2015

Question : 1

Lodging is a many to many relationship.
 Rent, payment to be made by person occupying different hotel rooms should be added as an attribute to -

- a) hotel
- b) ~~lodging~~
- c) person
- d) hero

→ If relationship is many to many we can't go any side.

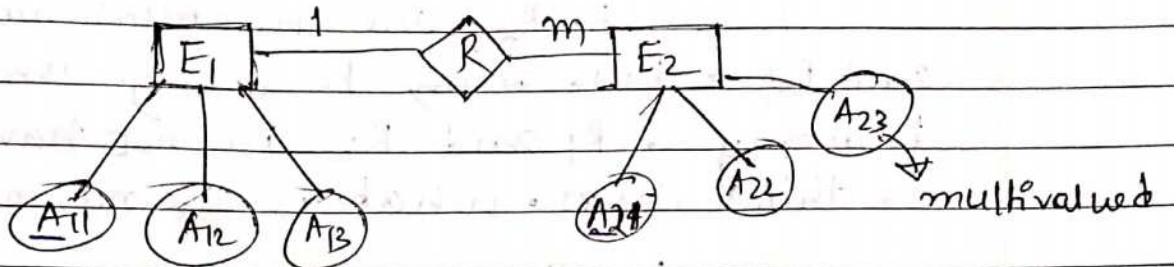
g' 2012

Question : 2

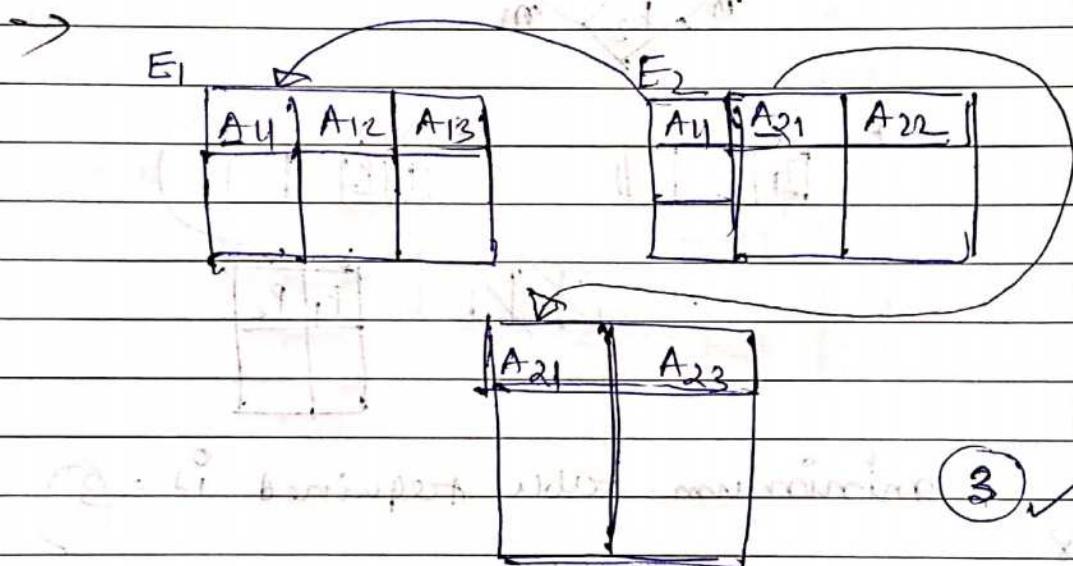
Given the basic ER and relational models, which of the following is incorrect?

- a) An attribute of an entity can have more than one value.
- b) An attribute of an entity can be composite.
- ~~c)~~ In a row of a relational table, an attribute can have more than one value.
- d) In a row of a relational table, an attribute can have exactly one value or a NULL value.

2004

Question : 3

minimum number of table = ? (3)



3 ✓

2012

Question : 4

The following table has two attributes 'A' and 'C' where 'A' is the primary key and 'C' is the foreign key referencing 'A' with on-delete cascade. The set of all tuples that must be additionally deleted to preserve referential integrity when the tuple (2,4) is deleted is

(or)

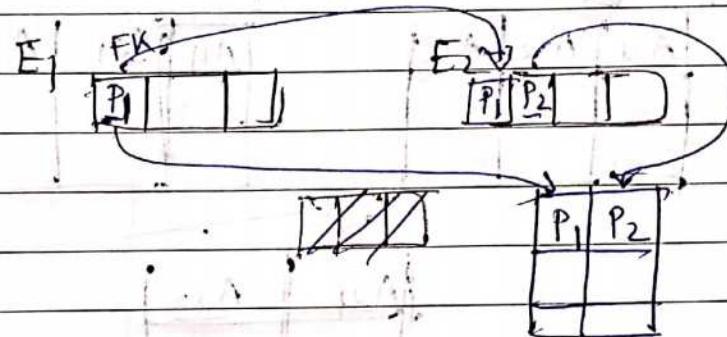
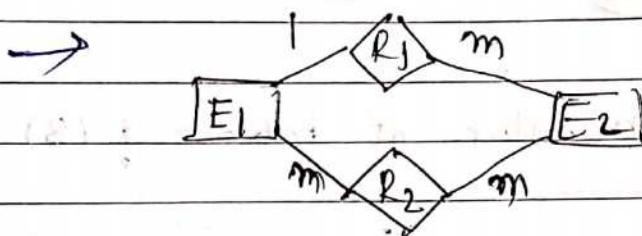
A	C
2	4
3	4
4	3
5	2
7	2
6	5
1	1

- (a) (3,4) and (6,9)
- (b) (5,2) and (7,2)
- (c) (5,4) (7,4) and (9,5)
- (d) (3,4) (4,3) and (6,4)

g' 2008

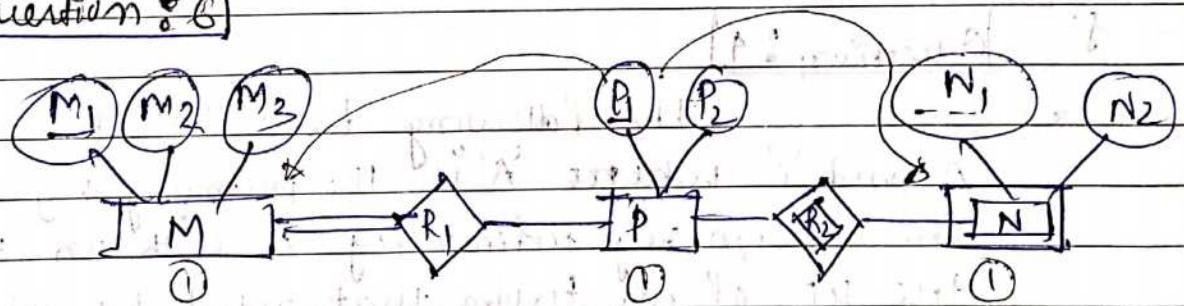
Question : 5 E_1, E_2 - two entities,

R_1, R_2 - are two relationship b/w E_1 and E_2 . R_1 is ^{one} many to many and R_2 is many to many. R_1 and R_2 does not have any attributes of their own. What is the number of tables?



minimum table required is = 3

g' 2008

Question : 6

The minimum number of tables needed -

- (A) 2 (B) 3 (C) 4 (D) 5.

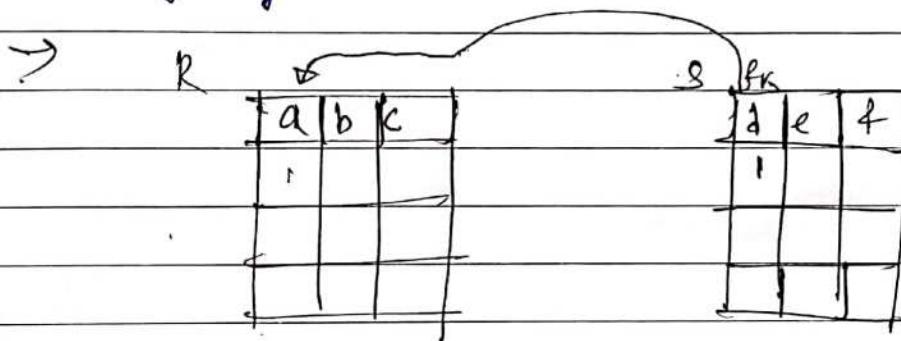
Which of the following is a correct attribute set for one of the tables for the correct answer of the above question -
 (A) {M₁, M₂, M₃, P₁} (B) {M₁, P₁, N₁, N₂} (C) {M₁, P, N₁} (D) {M₁, P₁}

Question :-

Let $R(a, b, c)$ and $S(d, e, f)$ be two relations.
 'd' is foreign key of S that refers to the primary key of ' R '. Consider the following four operations on ' R ' and ' S '.

- a) Insert into R . x) Delete from R
 x) " " S d) " " S

b) Which of these can cause violation of referential integrity constraint - (b, e)



NORMALISATION

Page No: 29

Date:

- Introduction of Normalisation =

Emp.

EID	EN	DID
1	a	1

Dep

DID	DName	SIP
1	CS	

EID	EN	DID	DN	SID
1	a	1	CS	10
2	b	1	CS	10
3		1	CS	10

anomalies (problems)

- Insertion.
- Deletion.
- Update.

This are all the Problem which will Occure If you try to reduce the Overhead of defining the Data Base by combining all the table.

Solution =

Divide the table as small table as possible. To avoid anomalies the ideal size of table is two attribut.



Divide big table into small small table which will contain less number of attributes in such a way that deriving not contain all this problem, In order to do that particular process which is called as NORMALISATION.

11. NORMALISATION (Contd)

- Functional dependency (FD) }
 → Candidate Key (CK). } used to evaluate
 formally.

• Introduction to FD :

A	B	C
1	a	b
2		
3		
4		

$A \rightarrow BC$

2 ab

If $t_1(A) = t_2(A)$

then

$t_1(BC) = t_2(BC)$

A	B
a	1
a	1
b	2
b	2

\leftarrow

(candidate key)
removing

redundant

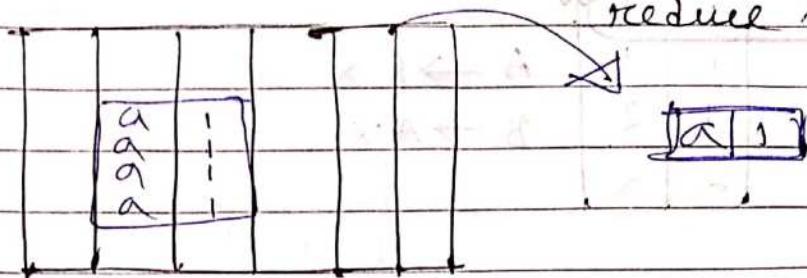
$(A) \rightarrow (B)$

A	B	C
a	1	d
a	1	e
a	1	f
a	2	g
b	2	h

(reduce redundancy) by
making a new table

A	B
a	1
b	2

new table.



reduce redundancy

✓ 1 Normal form (NF) } to go 1NF

✓ 2 NF

✓ 3 NF

✓ BCNF

We need FD & CK

BCNF

determine
 $X \rightarrow Y$

✓ Classification of FD into 3-Types -

(1) Trivial

$A \rightarrow A$

$AB \rightarrow A$

$X \supseteq Y$

(2) Non-Trivial

$A \rightarrow B$

$A \rightarrow BC$

$AB \rightarrow CD$

(3)

Semi non-Trivial

$AB \rightarrow BC$

$X \cap Y \neq \emptyset$

Here, X & Y can be set of a collection of attribute or subset of attribute

Example (FD) = $X \rightarrow Y$

Rule out the functional dependencies based on the tables:

①

$\checkmark EId \rightarrow Ename$

$X Ename \rightarrow EId$

ruled out..

Eid	Ename
1	a
2	b
3	b

left hand side should unique.

(2)

A	B
1	1
1	2
2	2

$$A \rightarrow B \times$$

$$B \rightarrow A \times$$

(3)

$$X A \rightarrow B$$

$$X B \rightarrow C$$

$$X B \rightarrow A$$

$$X C \rightarrow B$$

$$\checkmark C \rightarrow A$$

$$\checkmark A \rightarrow C$$

A	B	C
1	1	4
1	2	4
2	1	3
2	2	3
2	4	3

(4)

$$\checkmark A \rightarrow B$$

$$X B \rightarrow C$$

A	B	C
1	1	1
1	1	0
2	3	2
2	3	2

$$A \leftarrow A$$

$$A \leftarrow A$$

$$A \leftarrow A$$

$$A \leftarrow A$$

(5)

$$\checkmark XZ \rightarrow X$$

$$\checkmark XY \rightarrow Z$$

$$XZ \rightarrow Y$$

$$\checkmark Y \rightarrow Z$$

$$XXZ \rightarrow Y$$

X	Y	Z
1	4	3
1	5	3
4	6	3
3	2	2

(6)

$$\checkmark A \rightarrow B$$

$$XB \rightarrow A$$

$$\checkmark B \rightarrow C$$

$$\checkmark AC \rightarrow B$$

A	B	C
1	2	3
4	2	3
5	3	3

9/2000

Question - 1

Given the following relation instance -

X	Y	Z
1	4	2
1	5	3
1	6	3
3	2	2

Which of the following functional dependencies are satisfied by the instance -

- * (a) $XY \rightarrow Z$ and $Z \rightarrow Y$
- * (b) $YZ \rightarrow X$ and $Y \rightarrow Z$
- * (c) $YZ \rightarrow X$ and $X \rightarrow Z$
- * (d) $XZ \rightarrow Y$ and $Y \rightarrow X$

Question - 2

From the following instance of relation schema $R(A, B, C)$ we can conclude that:

A	B	C
1	1	1
1	1	0
2	3	2
2	3	2

* (a) A functionally determines B and B functionally determines C.

* (b) A functionally determines B and B does not functionally determine C.

* (c) B does not functionally determine C.

x(a) A set does not functionally determine B and B does not functionally determine C.

Formal definition of FDs (functional dependencies)

• Various usages of FDs:

Operations which have performance: FDs =

- (I) identifying additional FDs.
- (II) identifying keys.
- (III) identifying equivalences of FDs.
- (IV) finding minimal FD set.

Two methods (to perform this operations) =

(1) inference rules.

(2) closure set of attributes.

(1) Inference Rules:

(a) reflexive: $A \rightarrow B$ if $B \subseteq A$.

(b) Transitive: $A \rightarrow B$ and $B \rightarrow C$ then $A \rightarrow C$.

(c) Decomposition: if $A \rightarrow BC$ then $A \rightarrow B$ and $A \rightarrow C$

(d) Augmentation: if $A \rightarrow B$ then $AC \rightarrow BC$.

(e) Union: if $A \rightarrow B$ and $A \rightarrow C$, then $A \rightarrow BC$.

(f) Composition rule: if $A \rightarrow B$ and $C \rightarrow D$, then

$AC \rightarrow BD$.

(2) Closure closure set of attributes

FDS: $A \rightarrow B$

$B \rightarrow D$

$C \rightarrow DE$

$CD \rightarrow AB$

$$A^+ = \{B, D, A\}$$

$$B^+ = \{B, D\}$$

$$C^+ = \{D, E, C, A, B\}$$

$$(CD)^+ = \{C, D, E, A, B\}$$

$$(AD)^+ = \{B, A, D\}$$

Question - 1

Given,

FDS: $A \rightarrow B$ FDS: $AB \rightarrow CD$

$B \rightarrow$

$AF \rightarrow D$

$DE \rightarrow F$

$C \rightarrow GC$

$F \rightarrow E$

$GC \rightarrow A$

$$(CF)^+ = ? \quad ; \quad (A(F))^+ = ?$$

$$(BG)^+ = ? \quad ; \quad (AB)^+ = ?$$

$$(CF)^+ = \{C, F, G, E, A, D\}$$

$$(BG)^+ = \{B, G, A, C, D\}$$

$$(AF)^+ = \{A, F, D, E\}$$

$$(AB)^+ = \{A, B, C, D, G\}$$

Determining Candidate Keys =

→ with attribute (A B)

Candidate Key may possible = (A, B, AB)

→

with attribute (ABC)

Candidate Key = (A, B, C, AB, AC, BC, ABC)

* →

attribute (A₁, A₂, A₃, ..., A_n)

Candidate Key may possible = (2ⁿ - 1)

R(ABCD)

FDS:

A → B

B → C

C → D

D → A

① (ABCD)

④ (ABC)(ABD)(BCD)(ACD)

⑥ (AB)(AC)(AD)(BC)(BD)(CD)

⑦ (A)(B)(C)(D)

A⁺ = {A B C D}

B⁺ = {A B C D}

C⁺ = {A B C D}

D⁺ = {A B C D}

if A is candidate key then
 (AB) (AC) (AD) (ABC) (ABD) (ACD)
 (ABCD) will be Super Key.

Hence, for given example, FDS no. of candidate keys are '4'.

{A, B, C, D} = F(ABCD)

{A, B, C, D} = F(ACD)

{A, B, C, D} = F(BCD)

Question - q - 21996

$$R = (A, B, C, D, E, F)$$

$$FDs = (C \rightarrow F, E \rightarrow A, EC \rightarrow D, A \rightarrow B)$$

Candidate Key = ?

- (A) CD (B) BEC (C) AE (D) AC

$$\rightarrow ()^+ = (A \checkmark B \checkmark C \checkmark D \checkmark E \checkmark F)$$



$$CE = (\underline{C}, E, F, A, D, B) \rightarrow \text{Candidate Key.}$$

No. of superkey = 2^4

= 16 superkeys possible which contain CE.

Question - q - 2019

$$R = (E, F, G, H, I, J, K, L, M, N)$$

and $\{E, F, H\} =$

FDs: {

$$\{EF\} \rightarrow \{G\}$$

$$\{F\} \rightarrow \{I, J\}$$

$$\{EH\} \rightarrow \{KL\}$$

$$\{K\} \rightarrow \{M\}$$

$$\{L\} \rightarrow \{N\}$$

What is Key for R?

- (a) $\{E, F\}$ (b) $\{E, F, H\}$ (c) $\{E, F, H, K, L\}$ (d) $\{E\}$.

$$\rightarrow ()^+ = \{E, F, G, H, I, J, K, L, M, N\}$$

\downarrow
EFH

$$(EFH)^+ = \{E, F, H, G, I, J, K, L, M, N\} \checkmark$$

$$(EF)^+ = \{E, F, G, I, J\} \times$$

~~E~~

ans,

no of super key possible,

$$2^7 = 2^5 \times 2^2 \\ = 32 \times 4 \\ = 128 \quad - SK \text{ possible that contain } EFH$$

Question - g - 2005

$$R = (A, B, C, D, E, H)$$

$$FD = \{ A \rightarrow B, BC \rightarrow D, E \rightarrow C, D \rightarrow A \}$$

What are the candidate keys on R ?

~~(a) AE, BE~~ ~~(b) AE, BE, DE~~

~~(c) AEH, BEH, BCH~~

~~(d) (AEH, BEH, DEH)~~

→

$$\left(\begin{array}{c} \downarrow \\ EH \end{array} \right)^+ = (A, B, C, D, \cancel{E}, \cancel{H})$$

SK → $(EH)^+ = \{E, H, C\} \times$

~~(AEH)~~ \checkmark $(AEH)^+ = \{A, E, H, B, C, D\} \checkmark$

~~(BEH)~~ \checkmark $(BEH)^+ = \{B, E, H, C, D, A\} \checkmark$

~~(CEH)~~ \times $(CEH)^+ = \{C, E, H\} \times$

~~(DEH)~~ \checkmark $(DEH)^+ = \{D, E, H, A, B, C\} \checkmark$

$SK = (K_1 + K_2 + K_3) - K_1 K_2 - K_2 K_3 - K_1 K_3 + K_1 K_2 K_3$

~~Ex 8.6 & 8.7~~

Question - q - 2013

$$R = (A \ B \ C \ D \ E \ F \ G \ H)$$

$$\text{FDs} = \{ CH \rightarrow GC, A \rightarrow BC, B \rightarrow CFH, E \rightarrow A, F \rightarrow EG \}$$

How many Candidate Keys does the relation have?

$$(D)^+ = \{ A, B, C, D, E, F, G, H \}$$

$$① (D)^+ = \{ D \}$$

So, here,
4 - ~~Candidate~~
Key possible.
(AD)(BD)(FD)(ED).

$$② \checkmark (AD)^+ = \{ A, D, B, C, F, H, G, E \}$$

$$\checkmark (BD)^+ = \{ B, D, C, F, H, E, G, A \}$$

$$\times (CD)^+ = \{ C, D \}$$

$$\checkmark (ED)^+ = \{ E, D, A, B, C, F, H, G \}$$

$$\times (FD)^+ = \{ F, D, E, G, A, B, C, H \}$$

$$\times (GD)^+ = \{ G, D \}$$

$$\times (HD)^+ = \{ H, D \}$$

③

$$(CD)$$

$$(GD)$$

$$(HD)$$

not add

$$(ABEF)$$

add
(GCH)

A ~~→~~

B ~~→~~

E ~~→~~

F ~~→~~

$$\times (HGD)^+ = \{ H, G, D \}$$

$$\left\{ \begin{array}{l} \times (GCD)^+ = \{ G, C, D \} \\ \times (HCD)^+ = \{ H, C, D \} \end{array} \right.$$

ABD

④

$$\times (DCH)^+ = \{ D, C, G, H \}$$

(Example - 1) - candidate key.

$$\textcircled{1} \quad R = (A B C D E)$$

$$FDs = \{AB \rightarrow C, C \rightarrow D, B \rightarrow E\}$$

find candidate key.

$$\rightarrow (AB)^+ = (A B) \overset{\checkmark}{C} \overset{\checkmark}{D} \overset{\checkmark}{E}$$

$$\text{candidate key.} \quad | \text{SuperKey} = 2^3 = 8$$

$$\textcircled{2} \quad R = (A B C D E)$$

$$FD = \{AB \rightarrow C, C \rightarrow D, B \rightarrow EA\}$$

candidate key = ?

$$\rightarrow (\downarrow B) = (A \overset{\checkmark}{B} C \overset{\checkmark}{D} \overset{\checkmark}{E})$$

$$\textcircled{1} \quad \checkmark(B)^+ = \{A B C D E, B, E, A, C, D\}$$

B is the CK.

$$\checkmark(AB)^+ \neq \{A B C D E\}$$

$$\checkmark(CB)^+ = \{C B E A D\}$$

$$\checkmark(DB)^+ = \{D B E A C\}$$

$$\checkmark(EB)^+ = \{E B A C D\}$$

$$\text{no. of CK} = 2^4 = 16$$

$$\textcircled{3} \quad R = (A B C D E F)$$

$$FD = \{A \rightarrow B, C \rightarrow D, E \rightarrow F\}$$

$$\rightarrow (\downarrow ACE) = (A B C D E \overset{\checkmark}{F})$$

CK = ACE

$$\text{no. of SK} = 2^3 = 8$$

$$\checkmark(ACE)^+ = \{A C E B D F\}$$

(4)

$$R = ABCD$$

$$FD = \{AB \rightarrow CD, D \rightarrow A\}$$

$$CK = ?$$

$$\rightarrow (\downarrow)^+ = (\overline{A} \overline{B} \overline{C} \overline{D})$$

$$X(B)^+ = B$$

$$\checkmark(AB)^+ = (A B C D)$$

$$X(CB)^+ = (C B)$$

$$\checkmark(DB)^+ = (D B A C)$$

$$SK_1 \uparrow \quad SK_2 \uparrow \\ CK = ? (AB, DB)$$

$$SK = \cancel{Q} \cancel{P} \cancel{L} \cancel{M}$$

$$SK_1 + SK_2 - (SK_1 \cap SK_2)$$

$$= 2^2 + 2^2 - 2^1$$

$$= 8 - 3$$

~~CB~~

(5) $R = (ABCD)$

$$FD = \{AB \rightarrow CD, C \rightarrow A, D \rightarrow B\}$$

$$\rightarrow ()^+ = (\overline{A} \overline{B} \overline{C} \overline{D})$$

attri
buti, (1) $A^+ = (A)$

$$B^+ = (B)$$

$$C^+ = (AC)$$

$$D^+ = (DB)$$

Attri
buti, (2) $A \rightarrow B$

$$\checkmark AB^+ = ABCD$$

$$X AC^+ = AC$$

$$\checkmark AD^+ = AD BC$$

$$\checkmark BC^+ = BC AD$$

$$X BD^+ = BD$$

$$\checkmark CD^+ = CD AB$$

with (3) - attributes -

$$(AC) \times (CB) \\ \cancel{(ABC)} \\ (ABCD)$$

$$(AB)(AD)(BD)(CD)$$

4-CK is possible (AB, AD, BC, CD)

$$⑥ R = ABCDEF$$

$$FD = \{AB \rightarrow C, C \rightarrow D, D \rightarrow E, E \rightarrow F, F \rightarrow A\}$$

→

$$(.)^+ = (\overline{A} \overline{B} \overline{C} \overline{D} \overline{E} \overline{F})$$

①

$$\checkmark (CB)^+ = \{B\}$$

$$② \checkmark (AB)^+ = (A \ B \ C \ D \ E \ F)$$

$$\checkmark (CB)^+ = (C \ B \ D \ E \ F \ A)$$

$$\checkmark (DB)^+ = (D \ B \ E \ F \ A \ C)$$

$$\checkmark (EB)^+ = (E \ B \ F \ A \ C \ D)$$

$$\checkmark (FB)^+ = (F \ B \ A \ C \ D \ E)$$

$$CK = 5 \cdot (AB, CB, DB, EB, FB)$$

⑦

$$R = ABCDEF$$

$$FD = \{AB \rightarrow C, C \rightarrow D, D \rightarrow E, E \rightarrow F, F \rightarrow A\}$$

→

$$(.)^+ = (\overline{A} \overline{B} \overline{C} \overline{D} \overline{E} \overline{F})$$

①

$$A^f = A$$

$$B^f = B$$

$$\checkmark C^f = (C \ D \ E \ B \ F \ A)$$

$$\checkmark D^f = (D \ E \ B \ F \ A \ C)$$

$$E^f = (E \ F \ A)$$

$$F^f = (F \ A)$$

②

$$\checkmark (AB)^+ = (A \ B \ C \ D \ E \ F)$$

$$(A \cdot F)^+ = (A \ F)$$

$$(A \cdot F)^+ = (A \ F)$$

$$\checkmark (B \ E)^+ = (B \ E \ F \ A \ C \ D)$$

$$\checkmark (B \ F)^+ = (B \ F \ A \ C \ D \ E)$$

$$③ (FAE)^+ = (A \ F \ D \ F)$$

$$CK = 5 (C, D, AB, BF, BE)$$

(8) $R(ABCDEF)$

$$FD = A \rightarrow \cancel{ABCDEF}$$

$$BC \rightarrow ADEF.$$

$$DEF \rightarrow ABC.$$

$$\rightarrow ()^+ = (\cancel{ABCDEF})$$

$$(1) \checkmark A^+ = (A B C D E F)$$

$$\left\{ \begin{array}{l} \times B^+ = (B) \\ \times C^+ = (C) \\ \times D^+ = (D) \\ \times E^+ = (E) \\ \times F^+ = (F) \end{array} \right.$$

(2)

$$\checkmark B C^+ = (BCADEF)$$

$$\left\{ \begin{array}{l} BD^+ = \times \\ BE^+ = \times \\ BF^+ = \times \\ CD^+ = \times \\ CE^+ = \times \\ CF^+ = \times \end{array} \right.$$

(3)

$$\checkmark (DEF)^+ = \cancel{(DEFABC)}$$

$$\left\{ \begin{array}{l} DE^+ = \times \\ DF^+ = \times \\ EF^+ = \times \end{array} \right.$$

$$CK = (A, BC, (DEF))$$

(9) $R = (ABCDE)$

$$FD = \{ A \rightarrow B, B \rightarrow C, C \rightarrow D, D \rightarrow A \}$$

$$\rightarrow (\downarrow)^+ = (\cancel{ABCDE})$$

$$\times E^+ = \{E\}$$

$$\left| \begin{array}{l} \checkmark A E^+ = (ABCD) \\ \checkmark B E^+ = (BECDA) \\ \checkmark C E^+ = (CEDAB) \\ \checkmark D E^+ = (DEABC) \end{array} \right.$$

$$CK = 4$$

(10)

$$R = (ABCD E)$$

$$FD: A \rightarrow BC$$

$$CD \rightarrow E$$

$$B \rightarrow D$$

$$E \rightarrow A$$



$$()^+ = (\bar{A} \bar{B} \bar{C} \bar{D} \bar{E})$$

(1)

$$\checkmark A^+ = (ABC D E)$$

$$\begin{cases} B^+ = (BD) \\ C^+ = (C) \\ D^+ = (D) \end{cases}$$

$$\checkmark E^+ = (E A B C D)^-$$

(2)

$$\checkmark (BC)^+ = (BC D E A)$$

$$(BD)^+ = (BD)$$

$$\checkmark (CD)^+ = (CDA E B)$$

(3) ~~(BD)~~

$$CK = 4 (A, E, BC, CD)$$

Example - candidate Key for sub relation

(1) $R(ABCD)$

$$\{AB \rightarrow CD, D \rightarrow A\}$$

What are the Candidate keys of sub relation

 $R_1(BCD)$

$$\rightarrow B^+ = B$$

$$C^+ = C$$

$$D^+ = DA$$

This table is not going to have any CK with one attribute.

$$BCT = BC$$

$$CDT = CDA$$

$$\checkmark BD^+ = BDA$$

hence candidate key = BD.

(2) $R(ABCDEF)$

$$\{ AB \rightarrow C, B \rightarrow D, AD \rightarrow F, C \rightarrow D, D \rightarrow E, E \rightarrow F, E \rightarrow D \}$$

Find candidate keys for $R_1(DEF)$.

$$\rightarrow \checkmark D^+ = DEF$$

$$\checkmark E^+ = EDF$$

$$\times F^+ = F$$

For this table CK = D and E.

(3) $R(ABCDF)$

$$\{ A \rightarrow BC, CD \rightarrow F, B \rightarrow D, F \rightarrow A \}$$

What are the CK of $R_1(ABCE)$?

$$\rightarrow \checkmark A^+ = BCDEA$$

$$\times B^+ = \cancel{BD}$$

$$\times C^+ = C$$

$$\cancel{\times D^+} = \cancel{EABC}$$

$$\checkmark BC^+ = BCDEA$$

$$\times BD^+ = BD$$

$$\checkmark CDA = CDEAB$$

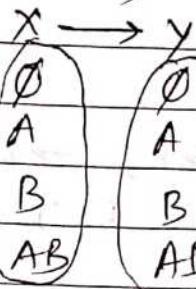
$$\checkmark BC^+ = BCDEA$$

for relation $R_1(ABCE)$ CK = (A, E, BC⁺)

Example: Checking additional FDs —

(i)

$R(AB)$

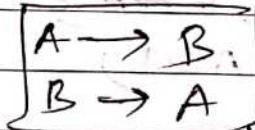


$\emptyset \rightarrow \emptyset$

Total possible FDs = 16

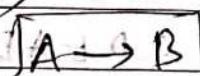
$\emptyset \rightarrow \emptyset$	$A \rightarrow \emptyset$	$B \rightarrow \emptyset$	$AB \rightarrow \emptyset$
$\emptyset \rightarrow A$	$A \rightarrow A$	$B \rightarrow A$	$AB \rightarrow A$
$\emptyset \rightarrow B$	$A \rightarrow B$	$B \rightarrow B$	$AB \rightarrow B$
$\emptyset \rightarrow AB$	$A \rightarrow AB$	$B \rightarrow AB$	$AB \rightarrow AB$

(i)



13-FDs are implied by

(ii)



(ii)-FDs are implied by



(ii)-FDs valid (according to)

10 additional FDs

can derive from $A \rightarrow B$

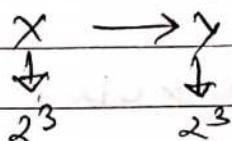
(Ex-2)

$R(ABC)$

FDS: $\{A \rightarrow B, B \rightarrow C\}$

What are all additional FDS that can derive from given FDS.

7



$$8 \times 8 = 64$$

$$\emptyset \rightarrow \emptyset - \textcircled{1}$$

$$A \rightarrow \{ABC\} - 2^3 = 8$$

$$B \rightarrow \{BC\} - 2^2 = 4$$

$$C \rightarrow \{C\} - 2^1 = 2$$

$$AB \rightarrow \{ABC\} - 2^3 = 8$$

$$BC \rightarrow \{BC\} - 2^2 = 4$$

$$AC \rightarrow \{ABC\} - 2^3 = 8$$

$$ABC \rightarrow \{ABC\} - 2^3 = 8$$

$$A^+ = ABC$$

$$A \rightarrow \emptyset$$

$$\rightarrow A$$

$$\rightarrow B$$

$$\rightarrow C$$

$$\rightarrow AB$$

$$\rightarrow BC$$

$$\rightarrow CA$$

$$c^t = c$$

$$B^+ = BC$$

$$\rightarrow \emptyset$$

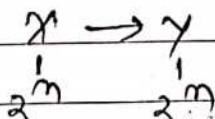
$$\rightarrow B$$

$$\rightarrow C$$

$$\rightarrow BC$$

43 - Functional Dependencies possible with given FDS.

$R(A_1, A_2, A_3, \dots, A_n)$



$$2^m \times 2^m = (2^{2m}) - \text{total FDs possible with } 'n' \text{ attributes}$$

Question - g - 2005

In a Schema with attributes A, B, C, D and E ; following set of FD's are given
 $A \rightarrow B$, $A \rightarrow C$, $CD \rightarrow E$, $B \rightarrow D$, $E \rightarrow A$.

Which of the following FDs is not implied by the above set ?

- a) $CD \rightarrow AC$ b) $BD \rightarrow CD$
 c) $BC \rightarrow CD$ d) $AC \rightarrow BC$

$$\begin{array}{l} \xrightarrow{\text{AC}} \text{FD}^+ = \underline{CD EA} \\ \xrightarrow{\text{AC}} \text{FD}^+ = \underline{AC BD} \\ \xrightarrow{\text{BC}} \text{FD}^+ = \underline{BCDEA} \quad \text{FD}^+ = \underline{BD} \end{array}$$

Equivalence of FDs

$$F: \{ \underline{A \rightarrow C}, \underline{AC \rightarrow D}, \underline{E \rightarrow AD}, \underline{E \rightarrow H} \}$$

$$G: \{ \underline{A \rightarrow CD}, \underline{E \rightarrow AH} \}$$

$$\begin{array}{c} * \xrightarrow{F \geq G} \\ \xrightarrow{G \geq F} \end{array} \quad \begin{array}{c} F \cong G \\ (\text{if } F \geq G \text{ and } G \geq F) \end{array}$$

$$A^+ = \overbrace{ACD}$$

$$E^+ = \overbrace{EAHD}$$

$$A^+ \rightarrow \underline{ACD}$$

$$E \rightarrow \underline{EAH(D)}$$

So, both the FDs are equivalent.

$$F \cong G$$

$$\textcircled{2} \quad F: \{A \rightarrow B, B \xrightarrow{*} C, C \rightarrow D\}$$

$$G: \{A \rightarrow BC, C \rightarrow D\}$$

$\checkmark [F \supseteq G]$ $\times [G \supseteq F]$ \rightarrow If both are satisfy then we can say $(F \cong G)$.

$$A \rightarrow ABCD$$

$$A \rightarrow BCD$$

$$B \rightarrow C \rightarrow D$$

F and G are not equivalent.

$$\textcircled{2} \quad F: \{A \rightarrow B, AB \rightarrow C, D \rightarrow AC, D \rightarrow E\}$$

$$G: \{A \rightarrow BC, D \rightarrow AB\}$$

$$\checkmark [F \supseteq G]$$

$$\times [G \supseteq F]$$

$$A \rightarrow ABC$$

$$D \rightarrow DACB$$

$$A \rightarrow ABC$$

$$D \rightarrow DABC$$

F and G are not equivalent. $(F \not\cong G)$ not equivalent.

\textcircled{3}

$$F: \{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$$

$$G: \{A \rightarrow BC, B \rightarrow A, C \rightarrow A\}$$

$$\checkmark [F \supseteq G]$$

$$\checkmark [G \supseteq F]$$

$$A \rightarrow ABC$$

$$B \rightarrow BCA$$

$$C \rightarrow ABC$$

$$A \rightarrow ABC$$

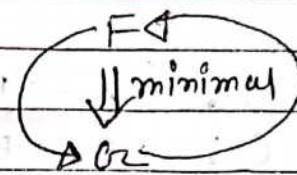
$$B \rightarrow BAC$$

$$C \rightarrow CAB$$

$F \cong G$

(HA = B + D + A)

• Minimise FDs set:



Procedure to find minimal set:

1) Split the FDs such that R.H.S contain single attribute.

Ex: $A \rightarrow BC \Rightarrow A \rightarrow B$ and $A \rightarrow C$

2) Find the redundant FDs and delete them from the set.

Ex: $\{A \rightarrow B, B \rightarrow C, A \rightarrow C\}$
 $\Rightarrow \{A \rightarrow B, B \rightarrow C\}$

3) Find the redundant attributes on L.H.S and delete them.

Ex: $AB \rightarrow C$, A can be deleted if B^+ contains 'A'.

(example)-

① FD: $\{A \rightarrow B, AC \rightarrow D, E \rightarrow AD, E \rightarrow H\}$

$\Rightarrow A \rightarrow B, AC \rightarrow D, E \rightarrow AD, E \rightarrow H$

② $A \rightarrow B, AC \rightarrow D, E \rightarrow AD, E \rightarrow H$

$$A^+ = A$$

$$(AC)^+ = AC$$

$$E^+ = EA \text{ (1)}$$

$$E^+ = ACD$$

③

$A \rightarrow C, A \rightarrow D, E \rightarrow A, E \rightarrow H$

$$C^+ = C$$

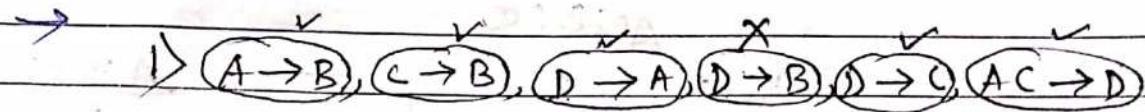
$$A^+ = AC$$

$A \rightarrow C, A \rightarrow D, E \rightarrow A, E \rightarrow H$

- minimal set

$\Rightarrow A \rightarrow CD, E \rightarrow AH$

② F: $\{A \rightarrow B, C \rightarrow B, D \rightarrow ABC, AC \rightarrow D\}$



$$A^+ = A \quad C^+ = C$$

$$D^+ = ADB$$

$$D^+ = DBC \quad D^+ = ADCB$$

$$(AC)^+ = ACB$$

2) $(A \rightarrow B), (C \rightarrow B), (D \rightarrow A), (D \rightarrow C), (AC \rightarrow D)$

minimal set of FDs. $C^+ = CB$

$$A^+ = BA$$

③ FD: $\{AB \rightarrow C, D \rightarrow E, E \rightarrow C\}$ is the minimal cover of

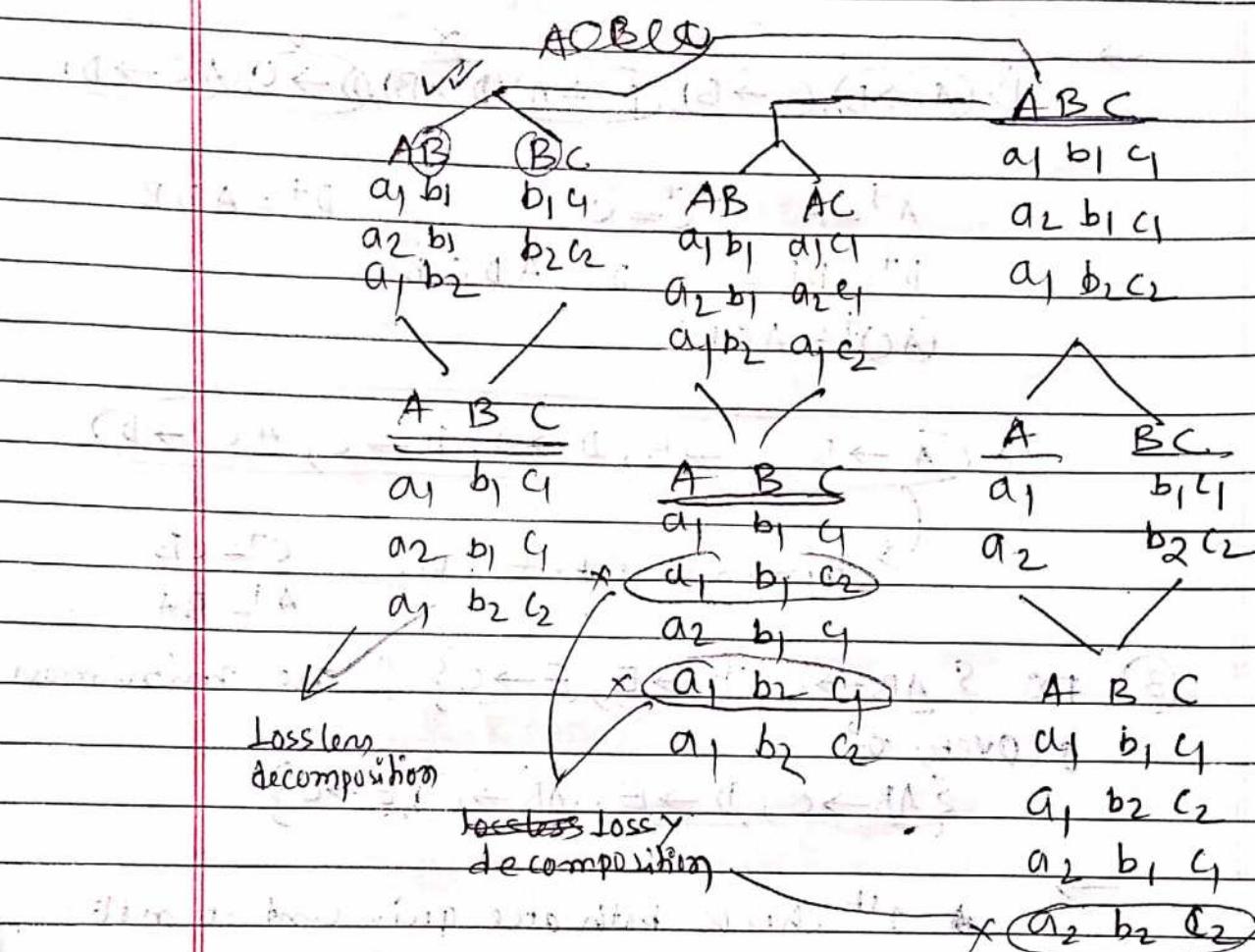
$$\{AB \rightarrow C, D \rightarrow E, (AB \rightarrow E), E \rightarrow C\}$$

→ 1st check both are equivalent or not.

$$\begin{array}{l|l} (AB)^+ \rightarrow A.B.C & AB^+ \rightarrow AB.C.E \\ D^+ \rightarrow DFC & D \rightarrow E \\ E^+ \rightarrow EC & E \rightarrow C \end{array}$$

both are not equivalent.

Lossless decomposition =



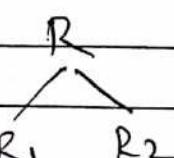
When extra tuple added that's call data loss.

- Every decomposition is not lossless decomposition.
- Some decomposition is lossless decomposition

* → we need lossless decomposition.

→ Key is one of the table decomposition, not be lose.

→ When divide the table
see the common
attribute



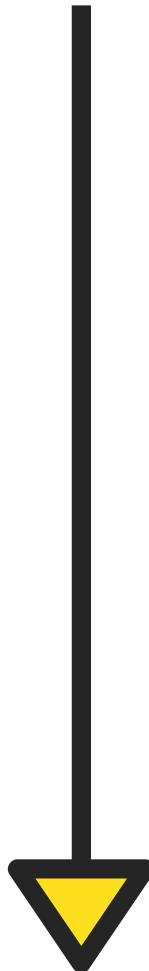
$$\begin{array}{l} R_1 \bowtie R_2 \rightarrow R - \text{lossy} \\ R_1 \bowtie R_2 = R - \text{lossless} \end{array}$$

$$(R, NR_2) \rightarrow R_1 \equiv (R_1 - R_2)$$

$$(R, NR_2) \rightarrow R_2 \equiv (R_2 - R_1)$$

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