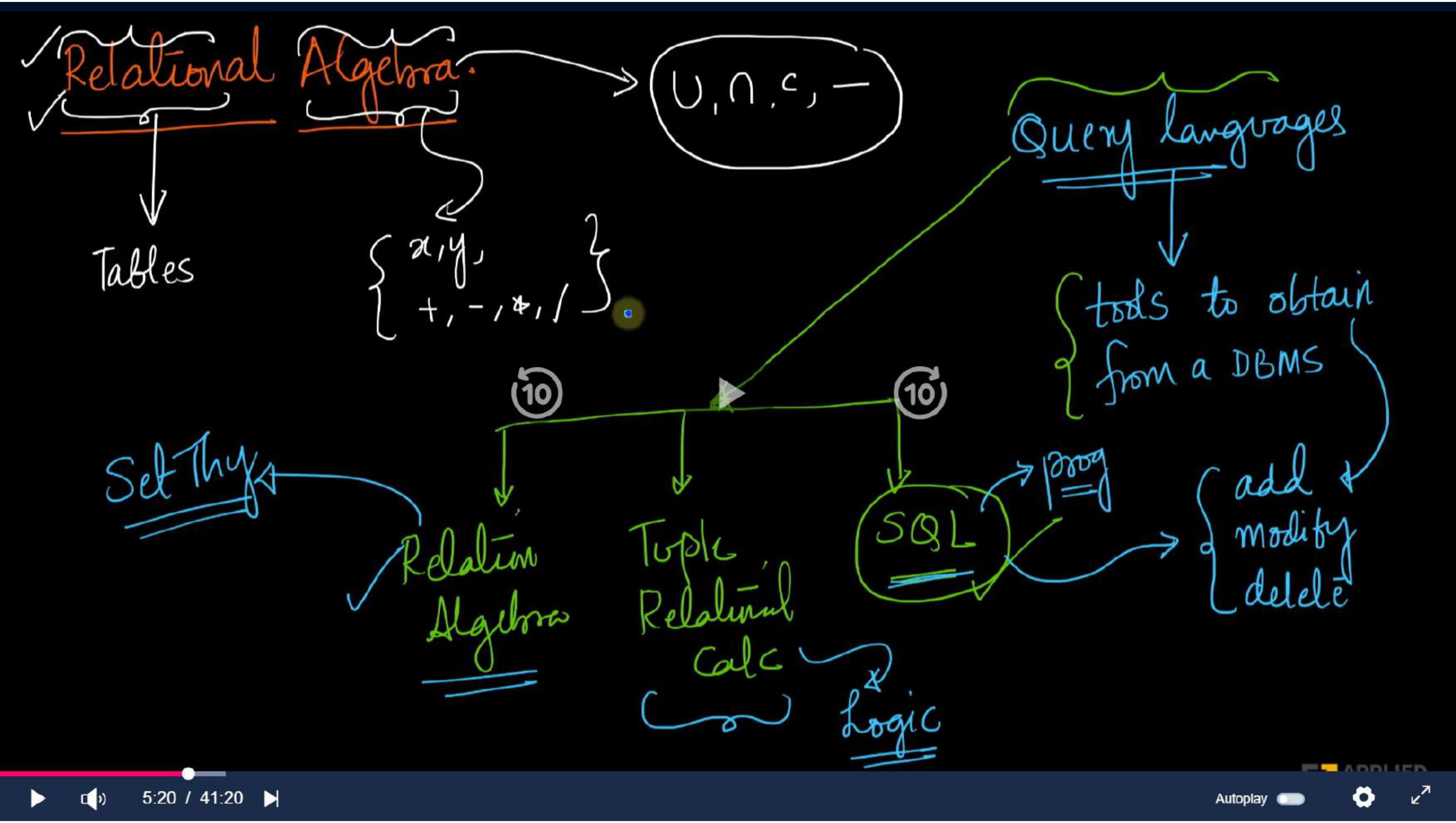
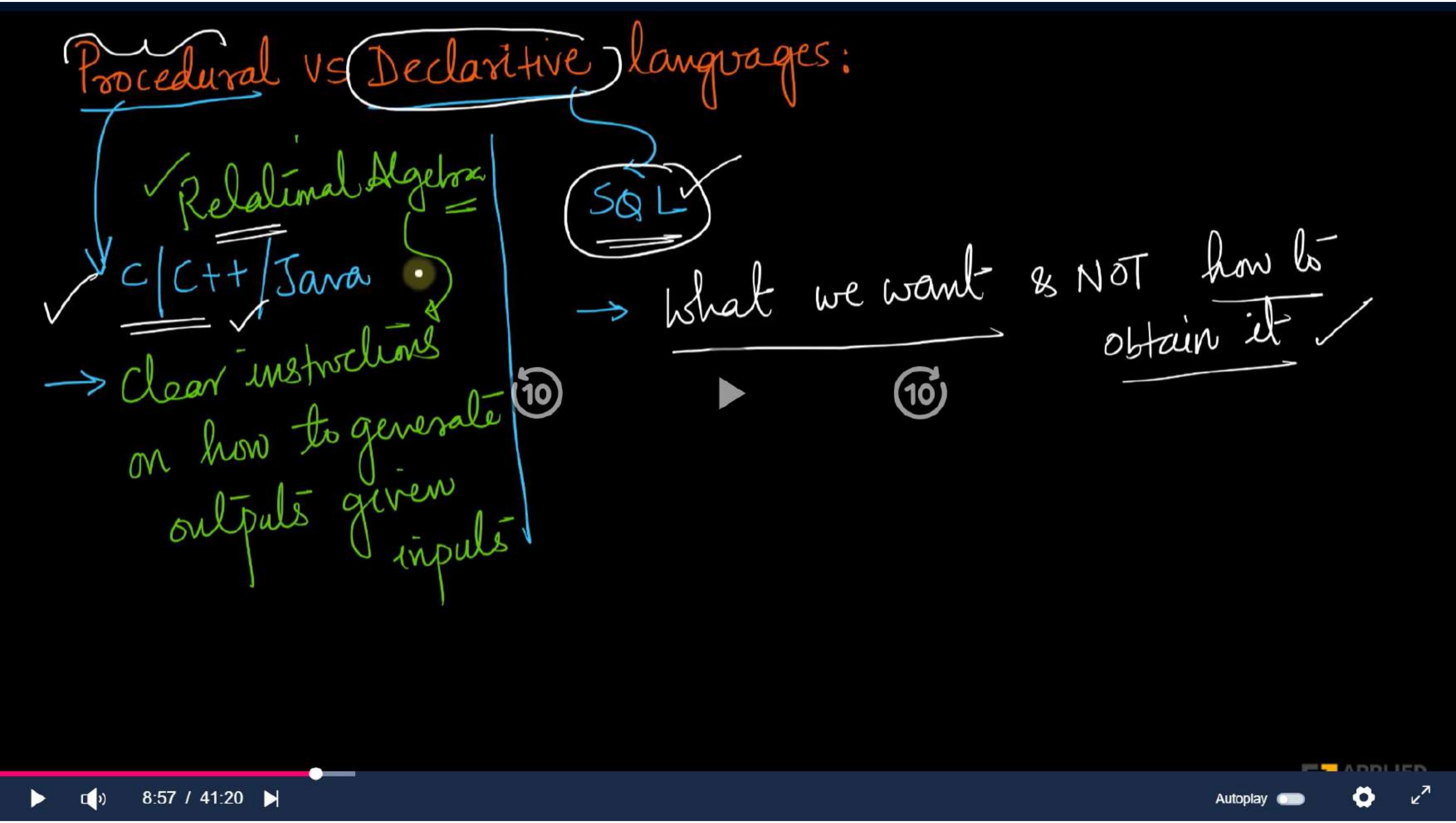


Relational Algebra
U, ∩, ⊂, −
Tables
x, y,
+, −, *, /
Query languages
tools to obtain from a DBMS
add
modify
delete
Set Thy
Relation Algebra
Tuple Relational Calc
SQL
prog
Logic
5:20 / 41:20
Autoplay


Procedural vs Declaritive languages:
Relational Algebra
C / C++ / Java
→ Clear instructions on how to generate outputs given inputs
SQL
→ What we want & NOT how to obtain it
8:57 / 41:20
Autoplay

Basic Relational Operators:

Projection: Π

$\Pi_{cid,\, cname}(Cust) =$ one-reln

cid	cname
i_1	n_1
i_2	n_1
i_3	n_2

Unary operators

cid	cname	czip
i_1	n_1	z_1
i_2	n_1	z_2
i_3	n_2	z_3

Cust

$\Pi_{cname}(Cust) =$ another-reln

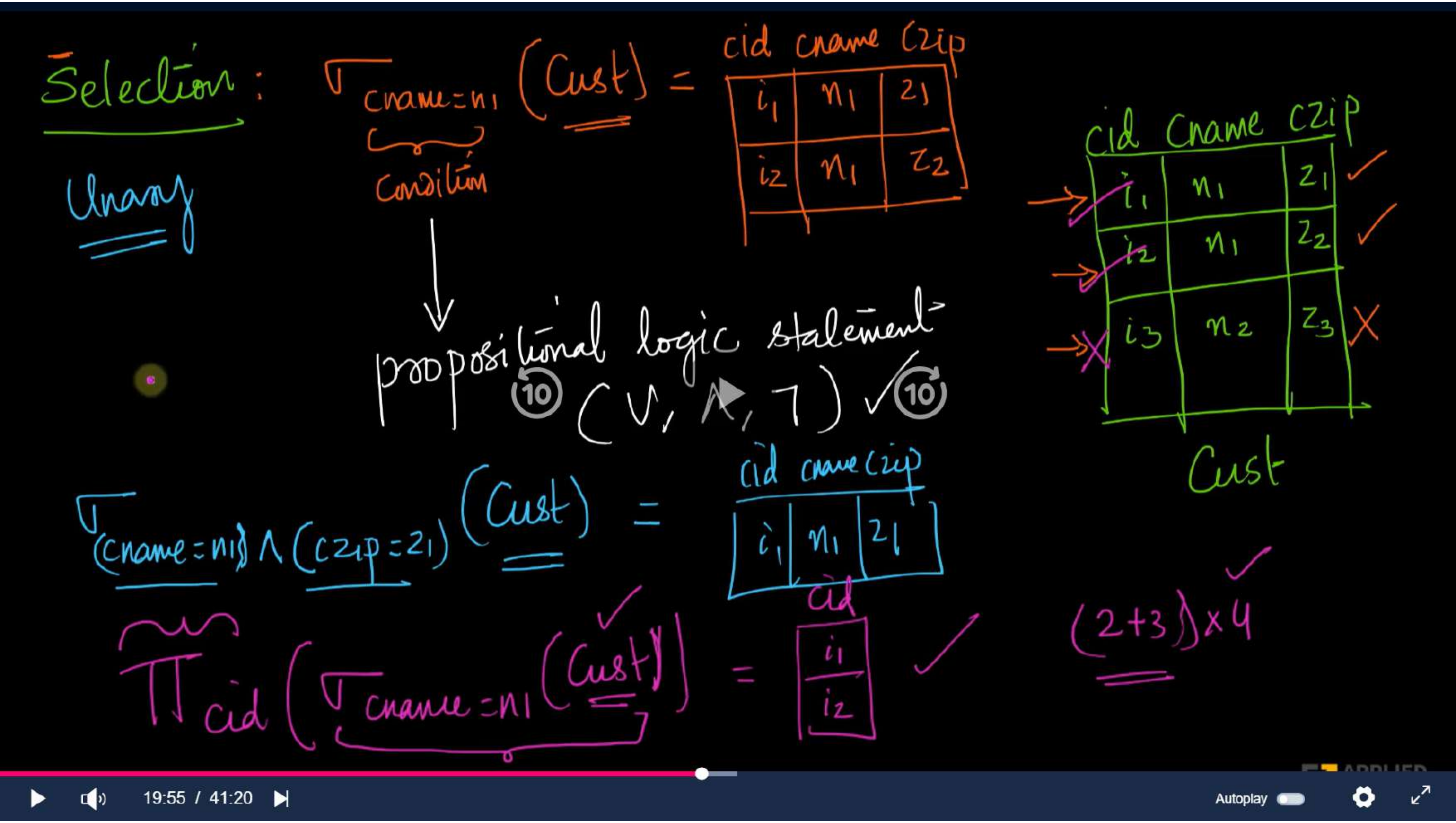
cname
n_1
n_1
n_2

✗

Relation is a set of tuples

cname
n_1
n_2

✓


Selection :
σ cname=n1 (Cust) =
cid cname czip
i1 n1 z1
i2 n1 z2
condition
Unary
propositional logic statement
(∨, ∧, ¬) ✓
cid cname czip
i1 n1 z1 ✓
i2 n1 z2 ✓
i3 n2 z3 ✗
Cust
σ (cname=n1) ∧ (czip=z1) (Cust) =
cid cname czip
i1 n1 z1
π cid (σ cname=n1 (Cust)) =
cid
i1
i2
(2+3)×4
19:55 / 41:20
Autoplay

Rename:

$$\rho_{\text{cname} \mid \text{custName}}(\text{Cust}) =$$

cid	custName	czip
i_1	n_1	z_1
i_2	n_1	z_2
i_3	n_2	z_3

cid	cname	czip
i_1	n_1	z_1
i_2	n_1	z_2
i_3	n_2	z_3

Cust

21:37 / 41:20 Autoplay

Set-operations : $\underbrace{\cup, \cap, -}$,

✓ $U = C1 \times C2 \times C3$

$R_1^c = U - R_1$

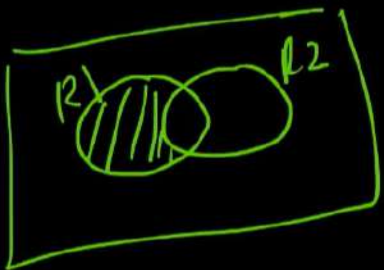
C1	C2	C3
1	a	α
2	b	β
3	c	γ

R_1

C1	C2	C3
1	a	α
4	d	δ
2	c	γ

R_2

$R1 \cup R_2 = \{(1, a, \alpha), (2, b, \beta), (3, c, \gamma), (4, d, \delta), (2, c, \gamma)\}$



$R_1 \cap R_2 = \{(1, a, \alpha)\}$

$R_1 - R_2 = R_1 - (R_1 \cap R_2) = \{(2, b, \beta), (3, c, \gamma)\}$

Relation is a set of tuples

✓ $\{R_1^c \Rightarrow$ dont often use

Compatibility of Relations:

✓ $R1(C1, C2, C3)$, $R2(C1, C2)$ → NOT Compatible

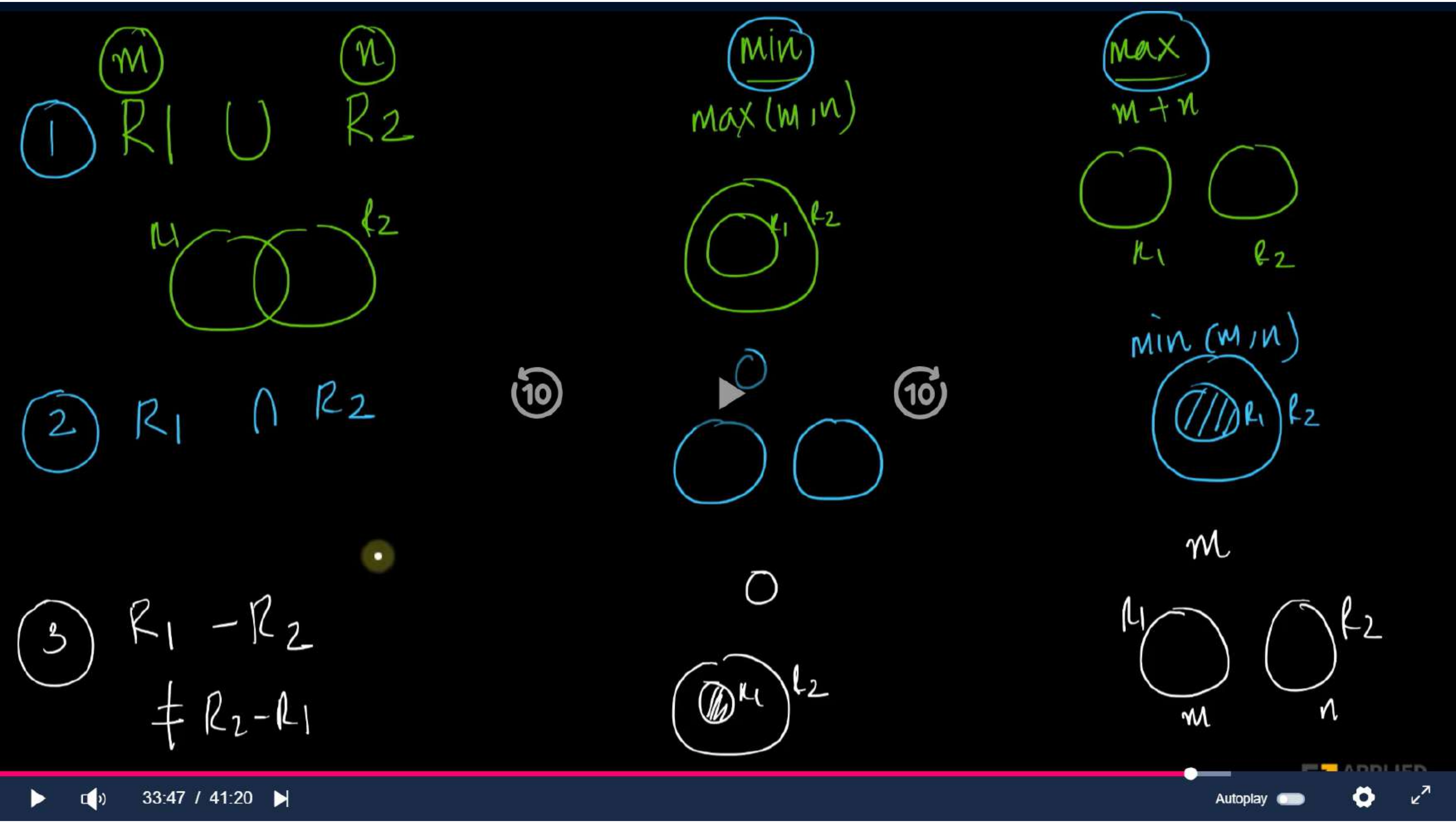
$R1(C1, C2, C3)$, $R2(C1, C2, C4)$ → NOT Compatible

$\underbrace{R1(C1, C2, C3)}$, $\underbrace{R2(C1, C2, C5)}$ → compatible

C5|C3

BAN

C3 & C5 have same domain



m
n
min
max
1 R1 ∪ R2
max (m, n)
m + n
R1
R2
2 R1 ∩ R2
min (m, n)
3 R1 − R2
≠ R2 − R1
0
m
n
33:47 / 41:20
Autoplay

Cross-product / Cartesian-product:

A, B

$R \subseteq A \times B$

{ Relation is a set of tuples ✓

$R1 \times R2$:

C1	C2	C3	C3	C4
1	a	x	α	β
1	a	x	1	α
2	b	y	α	β
2	b	y	1	α

C1	C2	C3
1	a	x
2	b	y

R1

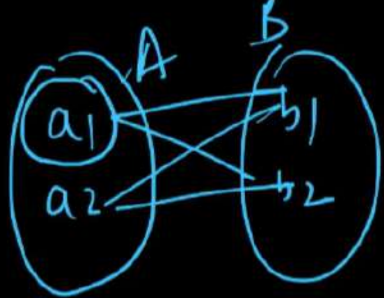
m

C3	C4
α	β
1	α

R2

n

$R1 \times R2$: $m \times n$ tuples



$A \times B = \{(a_1, b_1), (a_1, b_2), (a_2, b_1), (a_2, b_2)\}$

$$R1(\overbrace{r_1, r_2, r_3, \ldots r_m}) \times R_2(\overbrace{s_1, s_2, s_3, \ldots s_n})$$

$r_m \downarrow$ m-attrib

$s_n \downarrow$ n-attrib

$$= \left\{ (\underbrace{\overbrace{r_1, r_2, \ldots r_m}, \overbrace{s_1, s_2, \ldots s_n}}_{m+n \text{ tuple}}) \;\middle|\; (r_1, r_2 \ldots r_m) \in R_1 \text{ and } (s_1, s_2, \ldots s_n) \in R_2 \right\}$$

$R \times R$ ✓

$\underbrace{R1 \times R2 \times R3}$ ✓

$R \times R \times R$

Natural Join (Derived Operators) SQL

$R \bowtie S$ =

C1	C2	C3	C4
1	a	α	1

C1	C2	C3
1	a	α
2	b	β

R

C2	C3	C4
a	α	1
a	γ	2

S

R(C1, C2, C3) S(C2, C3, C4)

$$R \bowtie S = \pi_{C1,C2,C3,C4}\left(\sigma_{R.C2 = S.C2 \,\wedge\, R.C3 = S.C3}(R \times S)\right)$$

step by step.

R.C2

R.C1 R.C2 R.C3 S.C2 S.C3 S.C4

Conditional Join: Θ-joins $R \bowtie_{\theta} S$

R

C1	C2	C3
1	a	α
2	b	β

S

C2	C3	C4
a	α	1
a	γ	2

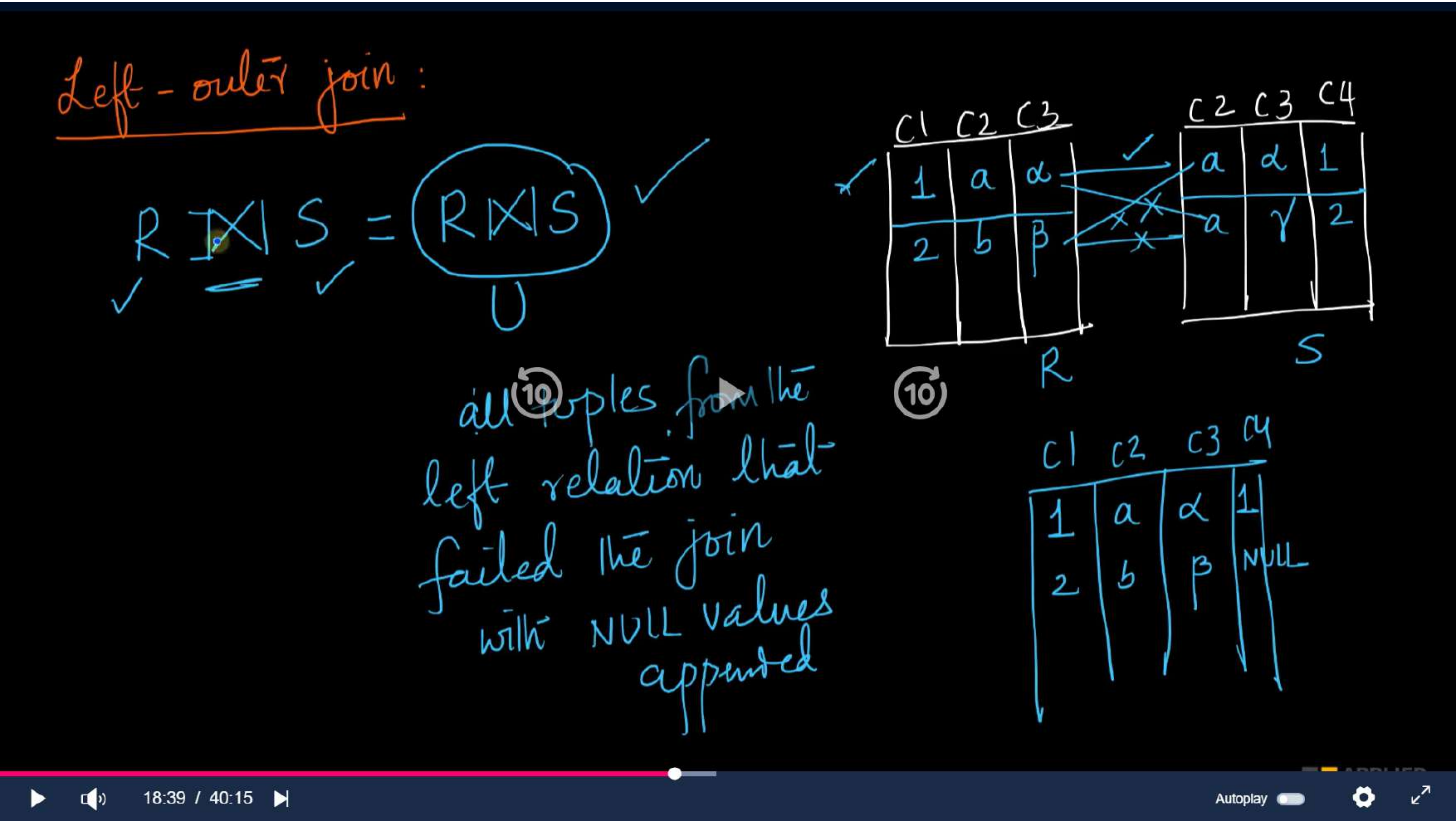
$$R \bowtie_{c} S = \sigma_{c}(R \times S)$$

$$R \bowtie_{R.C1 < S.C4} S = \sigma_{R.C1 < S.C4}(R \times S)$$

$\leq \quad \geq \quad < \quad >$

$\neq \quad =$

R.C1	R.C2	R.C3	S.C2	S.C3	S.C4
1	a	α	a	γ	2


Left-outer join :
R ⟕ S = R ⟕ S
U
C1 C2 C3
1 a α
2 b β
R
C2 C3 C4
a α 1
a γ 2
S
all tuples from the left relation that failed the join with NULL values appended
C1 C2 C3 C4
1 a α 1
2 b β NULL
18:39 / 40:15
Autoplay

Left-outer join :

$$R ⟕_c S = (R \bowtie_c S) \cup$$

all tuples from the left relation that failed the join with NULL values appended

R

C1	C2	C3
1	a	α
2	b	β

S

C2	C3	C4
a	α	1
a	γ	2

C1	C2	C3	C4
1	a	α	1
2	b	β	NULL

R ⟕ S = $(R \bowtie S)$

$\cup$

$\left(R - \pi_{r_1,\ldots r_n}(R \bowtie S) \right) \times (\text{NULL}, \text{NULL} \ldots)$

wikipedia

$R(r_1, r_2, \ldots\ldots r_n)$

$S(s_1, s_2, \ldots\ldots s_m)$

c1	c2	c3
1	a	α

c1	c2	c3
2	b	β

$\times$ (NULL)

2, b, β, NULL

24:31 / 40:15

Autoplay

Right outer join:

$$R ⟖ S = R \bowtie S$$
$$\cup$$
$$(NULL, NULL, \ldots) \times \underbrace{\left(S - \Pi_{S1,S2\ldots Sm}\left(\overbrace{R \bowtie S}\right)\right)}$$

wikipedia

R

C1	C2	C3
1	a	α
2	b	β

S

C2	C3	C4
a	α	1
a	γ	2

R ⟖ S

C1	C2	C3	C4
1	a	α	1
NULL	a	γ	2

28:23 / 40:15

Autoplay

Full outer join

$$R ⟗ S = R ⟕ S \cup R ⟖ S$$

R

C1	C2	C3
1	a	α
2	b	β

S

C2	C3	C4
a	α	1
a	γ	2

C1	C2	C3	C4
1	a	α	1
2	b	β	NULL
NULL	a	γ	2

Division

$R \div S$ $\quad$ R/S

$$\begin{cases} 2 \div 3 = 0.66 \\ 2 = 0.66 \times 3 \end{cases}$$

cid	Cat
1	C1
1	C2
2	C1
3	C2
4	C1
4	C2

R

Cat
C1
C2

S

$= T$

cid
1
4

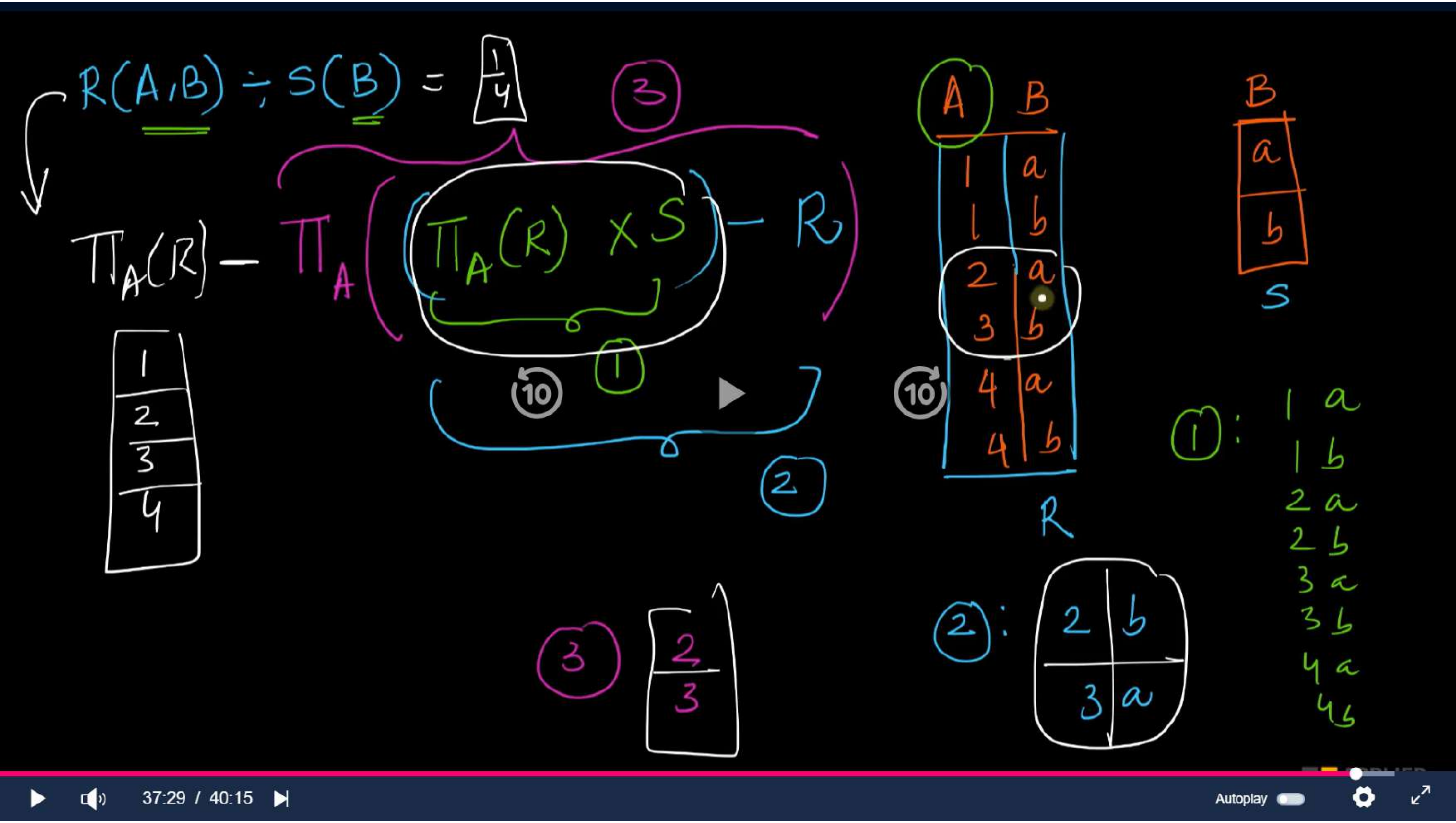
$T \times S$ ⊇?

1,	C1
1,	C2
4,	C1
4,	C2

$$\begin{cases} R \div S = T \\ R \supseteq T \times S \end{cases}$$

(Q) Customers whom purchased from every category

cid
1
4


R(A,B) ÷ S(B) =
1
4
ΠA(R) − ΠA((ΠA(R) × S) − R)
1
2
3
A B
1 a
1 b
2 a
3 b
4 a
4 b
R
B
a
b
S
1: 1 a
1 b
2 a
2 b
3 a
3 b
4 a
4 b
2: 2 b
3 a
3
2
3
1
2
3
4
37:29 / 40:15
Autoplay

Completeness: you can represent any relational operators using $\{\cup, -, \times, \Pi, \sigma\}$

Complete set of operators in RA

Consider the following relation P(X, Y, Z), Q(X, Y, T) and R(Y, V):
How many tuples will be returned by the following relational algebra query?

$$\pi_X(\sigma_{(P.Y = R.Y \wedge R.V = V2)}(P \times R)) - \pi_X(\sigma_{(Q.Y = R.Y \wedge Q.T > 2)}(Q \times R))$$

1

P

X	Y	Z
X1	Y1	Z1
X1	Y1	Z2
X2	Y2	Z2
X2	Y4	Z4

Q

X	Y	T
~~X2~~	~~Y1~~	~~2~~
X1	Y2	5
X1	Y1	6
~~X3~~	~~Y3~~	~~1~~

R

Y	V
Y1	V1
Y3	V2
Y2	V3
Y2	V2

X: $\boxed{X_2}$ − X: $\boxed{X_1}$

$A - B = A - (A \cap B)$

X: $\boxed{X_2}$ ✓

X: $\boxed{x1}$

6:15 / 22:22 Autoplay

Consider the relations r(A, B) and s(B, C), where s.B is a primary key and r.B is a foreign key referencing s.B.

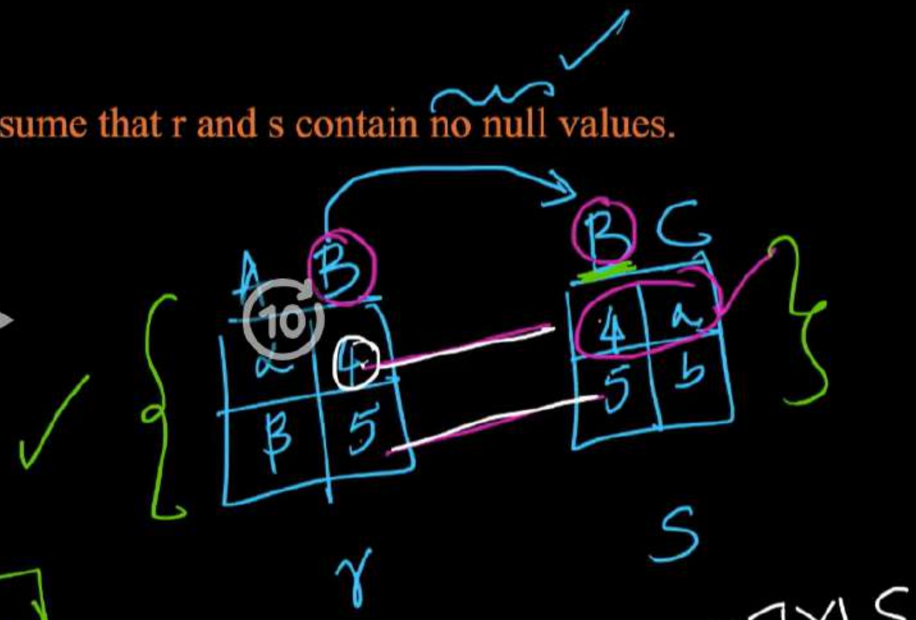
Consider the query

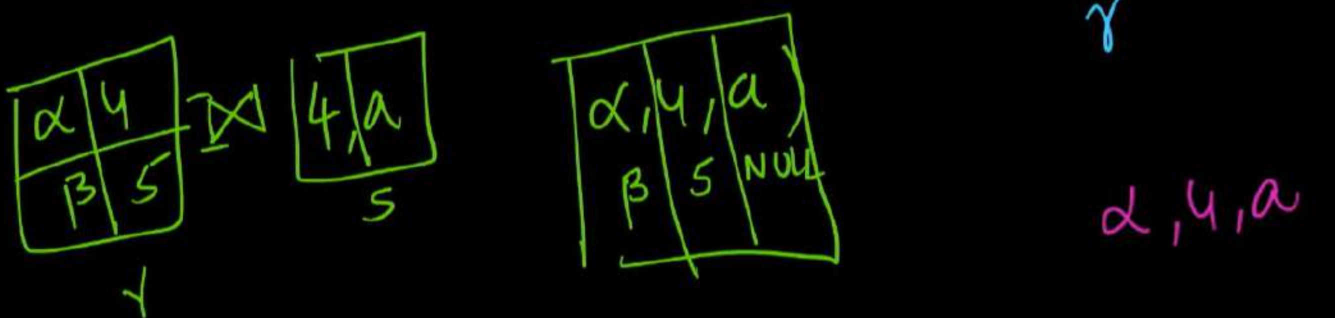
Q: $r \bowtie (\sigma_{B<5}(s))$

Let LOJ denote the natural left outer-join operation. Assume that r and s contain no null values.

Which one of the following is NOT equivalent to Q?

1. $\sigma_{B<5}$ (r ⋈ s) ✓
2. $\sigma_{B<5}$ (r LOJ s) → (α, 4, a)
3. r LOJ ($\sigma_{B<5}$(s))
4. $\sigma_{B<5}$(r) LOJ s





Consider a database that has the relation schema CR(StudentName, CourseName). An instance of the schema CR is as given below.

The following query is made on the database.

$T1 \leftarrow \pi_{CourseName}(\sigma_{StudentName='SA'}(CR))$

$T2 \leftarrow CR \div T1$

The number of rows in T2 is 4.

CourseName

T1 =

CA
CB
CC

StudentName

T2 =

SA
SC
SD
SF

CR	
StudentName	CourseName
SA	CA
SA	CB
SA	CC
SB	CB
SB	CC
SC	CA
SC	CB
SC	CC
SD	CA
SD	CB
SD	CC
SD	~~CD~~
SE	CD
SE	CA
SE	CB
SF	CA
SF	CB
SF	CC

Consider two relations $R_1(A,B)$ with tuples (1,5), (3,7) and $R_2(A,C)$ = (1,7), (4,9). Assume that R(A,B,C) is the full natural outer join of R_1 and R_2. Consider the following tuples of the form (A,B,C): a = (1,5,null) , b = (1,null,7), c = (3,null,9), d = (4,7,null), e = (1,5,7), f = (3,7,null) , g = (4,null,9). Which one of the following statements is correct?

Which one of the following statements is correct?

1. R contains a,b,e,f,g but not c,d.
2. R contains all a,b,c,d,e,f,g.
3. R contains e,f,g but not a,b.
4. R contains e but not f,g.

R_1

A	B
1	5
3	7

R_2

A	C
1	7
4	9

$R = R_1 ⟗ R_2$

R:

A	B	C
1	5	7
3	7	NULL
4	NULL	9

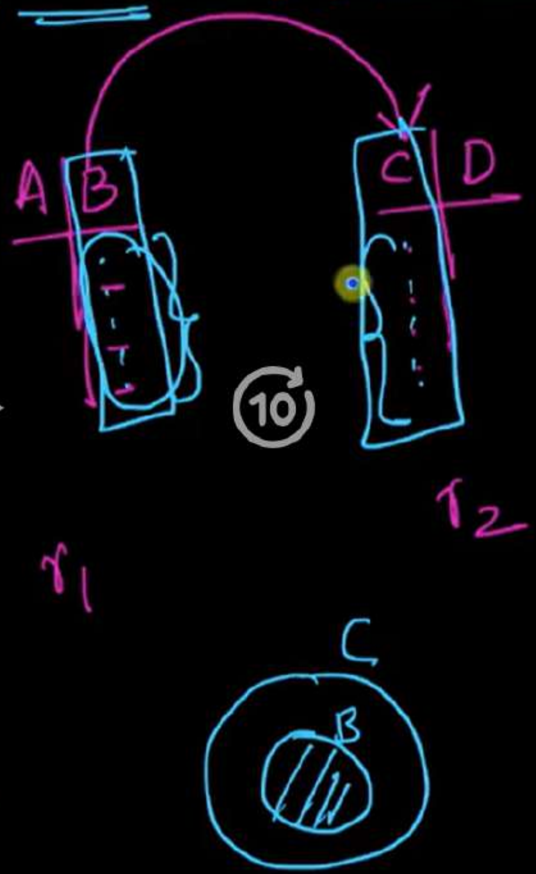
Suppose (A, B) and (C,D) are two relation schemas. Let r1 and r2 be the corresponding relation instances. B is a foreign key that refers to C in r2. If data in r1 and r2 satisfy referential integrity constraints, which of the following is ALWAYS TRUE?

(A) $\Pi_B(r_1) - \Pi_C(r_2) = \varnothing$

(B) $\Pi_C(r_2) - \Pi_B(r_1) = \varnothing$

(C) $\Pi_B(r_1) = \Pi_C(r_2)$

(D) $\Pi_B(r_1) - \Pi_C(r_2) \neq \varnothing$



$B - C = \phi$

$C \supseteq B$

$\boxed{B \subseteq C}$

22:03 / 22:22

Autoplay