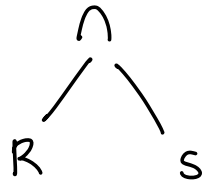
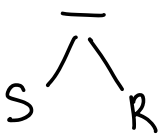
1

a)



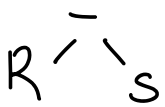
A	B	C
c	a	3
b	b	1
b	c	3
c	c	3

b)



A	B	C
c	c	2
a	b	3
a	a	1

c)

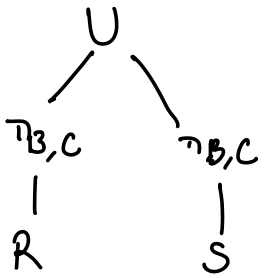


A	B	C
b	a	2
c	a	4

d)

A	B
c	c
c	a
b	b
a	b
b	c
a	a

e)

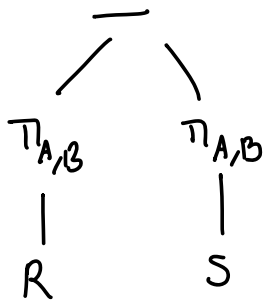


$R_{B,C}$	
c	3
~~c~~	~~5~~
a	3
b	1
a	4
a	2

$S_{B,C}$	
c	2
a	3
b	1
b	3
c	3
a	1
c	3

B	C
c	3
a	3
b	1
a	4
a	2
c	2
b	3
a	1

f)

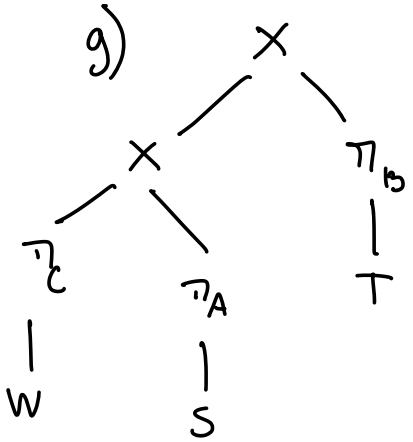


$R_{A,B}$
b c
c c
c a
b b
~~c a~~
b a

$S_{A,B}$
c c
c a
b b
a b
b c
a a
~~c c~~

A B
a b

g)



W_C
1
2
3
4

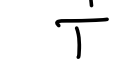
S_A
c
b
a

T_B
a
c
b
a

W_C	S_A	T_B
48 tuples		

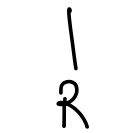
$W_C \times S_A$	
1	c → 4
1	b → 4
1	a → 4
2	c → 4
2	b → 4
2	a → 4
3	c → 4
3	b → 4
3	a → 4
4	c → 4
4	b → 4
4	a → 4

h)



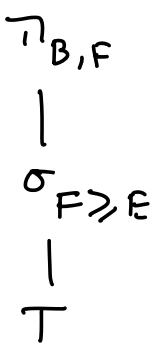
B	D	E	F
b	b	3	2
a	b	3	2
b	c	4	1

i)



A	B	C
b	c	3
c	a	3
c	a	4
b	a	2

j)

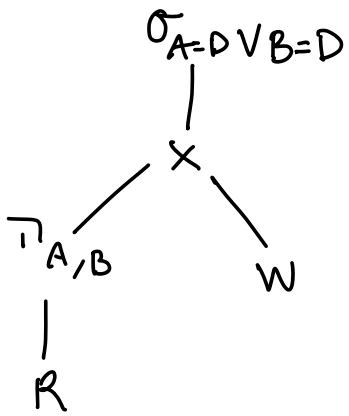


$\sigma_{F \geq E}(T)$

B	D	E	F
a	a	1	2
c	d	2	4
a	a	2	3
d	a	1	4

B	F
a	2
c	4
a	3
d	4

k)



$\pi_{A,B}(R)$

A	B
b	c
c	c
c	a
b	b
b	a

$\pi_{A,B}(R) \times W$

	C	D
b	c	1 a
→ b	c	2 b
→ b	c	3 c
b	c	4 d
c	c	1 a
c	c	2 b
→ c	c	3 c
c	c	4 d

A	B	C	D
b	c	2	b
b	c	3	c
c	c	3	c
c	a	1	a

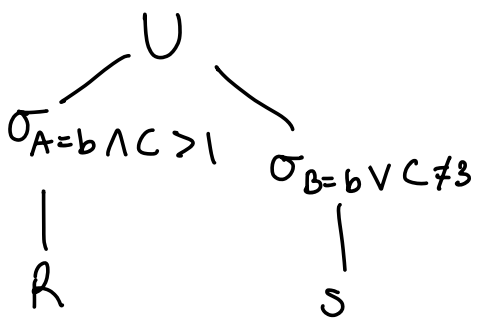
→ c	a	1	a
c	a	2	b
→ c	a	3	c
c	a	4	d

b	b	1	a
→ b	b	2	b
b	b	3	c
b	b	4	d

→ b	a	1	a
→ b	a	2	b
b	a	3	c
b	a	4	d

c	a	3	c
c	a	1	a
b	b	2	b
b	a	1	2
b	a	2	b

l)



$\sigma_{A=b \wedge C>1}(R)$

A	B	C
b	c	3
b	a	2

$\sigma_{B=b \vee C \neq 3}$

A	B	C
c	c	2
b	b	1
a	b	3
a	a	1

U

A	B	C
b	c	3
b	a	2
c	c	2
b	b	1
a	b	3
a	a	1

m) $\sigma_{\neg(B=d)}$

|
T

$\sigma_{\neg(B=d)}(T)$

B	D	E	F
a	a	1	2
c	d	2	4
b	b	3	2
a	a	2	3
b	c	4	1

n)

$\pi_{A,B,R.C,D}$

|

$\sigma_{R.C=W.C}$

|

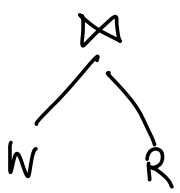
X

/ \

R W

A	B	C	D
b	c	3	c
c	c	3	c
c	a	3	c
b	b	1	a
c	a	4	d
b	a	2	b

o)

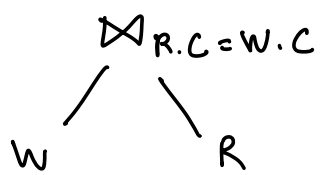


Natural Join

W.C	D	A	B
1	a	b	b
2	b	b	a
3	c	b	c
3	c	c	c
3	c	c	a
4	d	c	a

* order does not matter *

p)

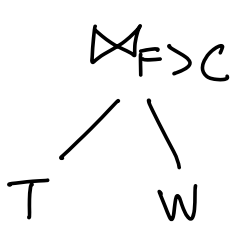


Equi-join

↳ no projection

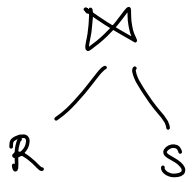
W.C	D	A	B	R.C
1	a	b	b	1
2	b	b	a	2
3	c	b	c	3
3	c	c	c	3
3	c	c	a	3
4	d	c	a	4

q)



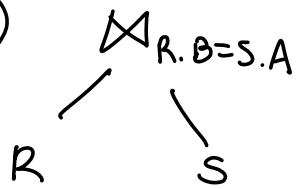
B	T.D	E	F	C	W.D
a	a	1	2	1	a
c	d	2	4	2	b
c	d	2	4	3	c
c	d	2	4	4	d
b	b	3	2	1	a
d	b	3	2	1	a
a	a	2	3	1	a
a	a	2	3	2	b
a	a	1	4	1	a
d	a	1	4	2	b
d	a	1	4	3	d

r)



A	B	C
b	c	3
c	c	3
c	a	3
b	b	1

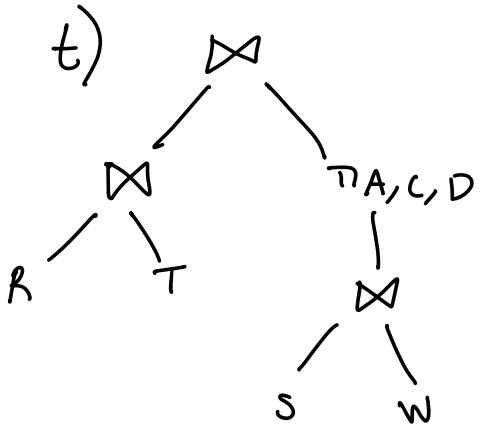
s)



R.A	R.B	R.C	S.A	S.B	S.C
b	c	3	c	c	2
b	c	3	c	a	3
b	c	3	c	c	3
c	c	3	c	c	2
c	c	3	c	a	3
c	c	3	c	c	3

↳ 2a's, 2b's, 2a's, 2a's

t)



R ⋈ T

A	R.B	C	D	E	F
b	c	3	d	2	4
c	c	3	d	2	4
c	a	3	a	1	2
c	a	3	a	2	4
b	b	1	b	3	2
b	b	1	c	4	1
c	a	4	a	1	2
c	a	4	a	2	4
b	a	2	a	1	2
b	a	2	a	2	4

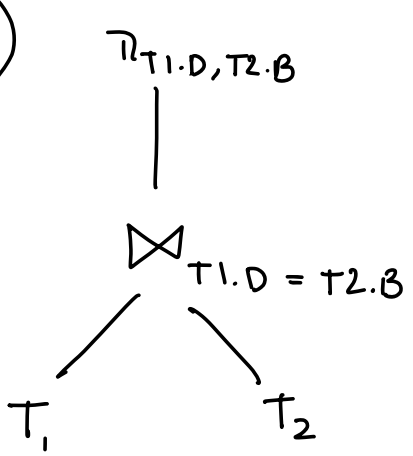
πA,C,D(S ⋈ W)

A	S.C	D
c	2	b
c	3	c
b	1	a
a	3	c
b	3	c

a	1	a
c	3	c

$\emptyset$

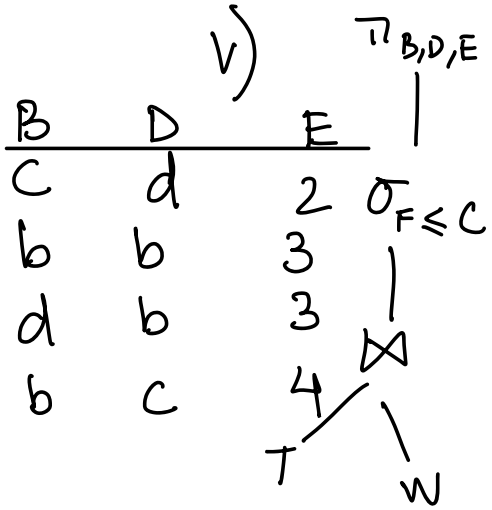
4)



T1.D	T2.B
a	a
d	d
b	b
c	c

T1.B	T1.D	E	F	T2.B	D	E	F
a	a	1	2	a	a	1	2
a	a	1	2	a	a	2	3
c	d	2	4	d	b	3	2
c	d	2	4	d	a	1	4
b	b	3	2	b	b	3	2
b	b	3	2	b	c	4	1
d	b	3	2	b	b	3	2
d	b	3	2	b	c	4	1
a	a	2	3	a	a	1	2
a	a	2	3	a	a	2	3
b	c	4	1	c	d	2	4

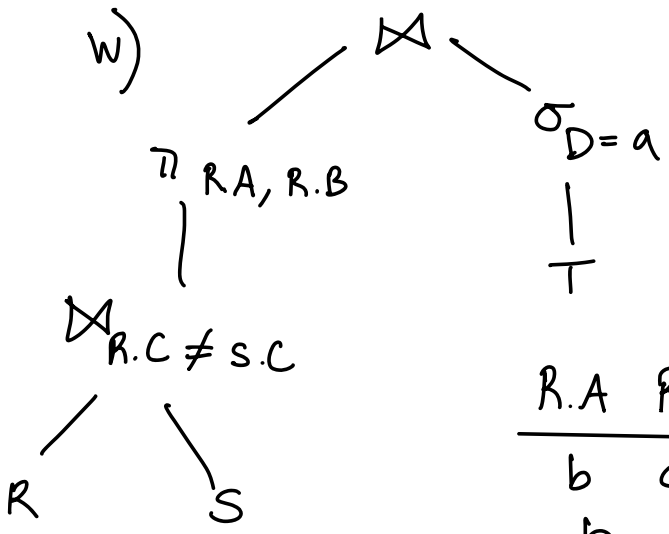
v)



B	D	E
c	d	2
b	b	3
d	b	3
b	c	4

	B	T.D	E	F	C
	a	a	1	2	1
→	c	d	2	4	4
→	b	b	3	2	2
→	d	b	3	2	2
	a	a	2	3	1
→	b	c	4	1	3
	d	a	1	4	1

w)



R.A	R.B
b	c
c	c
c	a
b	b
b	a

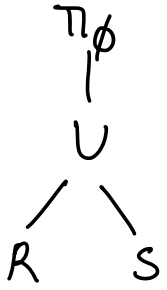
T

B	D	E	F
a	a	1	2
a	a	2	3
d	a	1	4

R.A	R.B	D	E	F
c	a	a	1	2
c	a	a	2	3
b	a	a	1	2
b	a	a	2	3

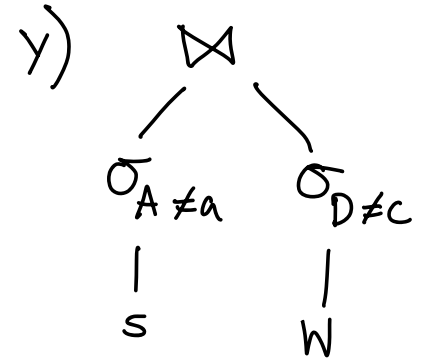
R.A	R.B	R.C	S.A	S.B	S.C
b	c	3	c	c	2
b	c	3	b	b	1
b	c	3	a	a	1
c	c	3	⋮		
b	b	1			
c	a				

x)



$\boxed{\emptyset}$

y)



S

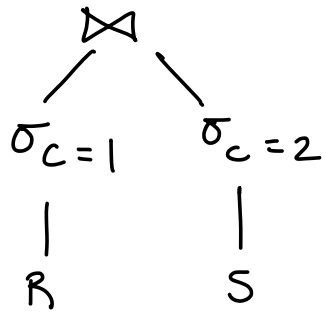
A	B	C
c	c	2
c	a	3
b	b	1
b	c	3
c	c	3

W

C	D
1	a
2	b
4	d

A	B	S.C	D
c	c	2	b
b	b	1	a

z)



R

A	B	C
b	b	1

S

A	B	C
c	c	2

$\emptyset$

2

1) $\Pi_{Name}\left(\sigma_{M.From \leq 1970 \wedge M.To \geq 1970}(M)\right)$

2) $\left(\left(\Pi_{Name,\ BandID}\left(\sigma_{M.From \leq 1970 \wedge M.To \geq 1970}(M)\right)\right) \bowtie_{M.BandID = B.Id} B\right)$

$\Pi_{M.Name,\ B.Name}$

3) $\Pi_{M.Name,\ M.From,\ M.To}\left(\sigma_{B.Name = Gong}\left(M \bowtie_{BandId = Id} B\right)\right)$

4) $\Pi_{M.Name}\left(\sigma_{B.Name = Gong \wedge (M.From \leq 1974 \wedge M.To \geq 1974}(\uparrow)\right)$

5) $\Pi_{M.Name,\ B.Name}\left(\sigma_{B.Name = `King\ Crimson' \wedge (B.FormedIn = M.From}\left(M \bowtie_{BandId = Id} B\right)\right)$

6) $\Pi_{B.Name}\left(\sigma_{A.Title = Loaded}\left(A \bowtie_{BandId = Id} B\right)\right)$

7) $\Pi_{B.Name}\left(\sigma_{M.Name = `Jim\ Morrison'}\left(M \bowtie_{BandId = Id} B\right)\right)$

8) $\Pi_{A.Title,\ A.Year,\ B.Name}\left(\sigma_{B.Country = UK}\left(\left(A \bowtie_{AId = ID} B\right)\right)\right)$

9) $\rho_F\left(\Pi_{B.Id,\ B.Name}\left(\sigma_{A.Title = Fragile}\left(A \bowtie_{AId = Id} B\right)\right)\right)$

$\Pi_{M.Name}\left(M \bowtie_{BandId = Id} F\right)$

10) $\left(\sigma_{B.Name = Pink\ Floyd}\left(M \bowtie_{BandId = Id} B\right)\right)$

$\rho_P\left(\Pi_{M.Name,\ BandId,\ From,\ To}(\uparrow)\right)$

$\sigma_{M.From > P.Year \vee M.To < P.Year}\left(\left(\uparrow \bowtie_{BandId = AId} P\right)\right)$

$\sigma_{A.Name = Meadle}(A)$

11) $\left(\left(\rho_{A1}(A) \bowtie_{(A1.Id < A2.Id) \wedge (BandId = BandId) \wedge (A1.Year = A2.Year)} \rho_{A2}(A)\right) \bowtie_{BandId = Id} B\right)$

$\Pi_{B.Name,\ A1.Title,\ A1.Year}$ (↑)

12) $\left(M \bowtie_{BandId = Id} B\right) - \sigma_{Name = \text{`Lou Reed'}}\left(M \bowtie_{BId = Id} B\right)$

$\Pi_{B.Name}$ (↑)

13) $\Pi_{A.Title,\ A.Year}\left(\left(\sigma_{rn > 1972}(M) \bowtie_{M.BandId = Id} B\right) \bowtie_{Id = A.Id} (A)\right)$

14) $\left(A \bowtie_{(BandId = AId) \wedge (A.Year < M.From)} \sigma_{M.Name = \text{`Adrian Belew'}}(M)\right)$

$\Pi_{A.Title,\ A.Year}$

15) $\left(\rho_{M1}(M) \bowtie_{(M1.Name = M2.Name) \wedge (M1.BandID < M2.BandID)} \rho_{M2}(M)\right)$

$\Pi_{M1.Name}$ (↑)

Problem 3

1) A candidate key for this table would be (FirstName, LastName, TeamName, Season). This is a candidate key because FirstName and LastName are unique for a team, and those team names are unique. Finally, the season is included to decipher which season this player's stats are for.

2) This is not a candidate key because a player on the same team can have the same amount of shots and rebounds, for example a players that is on the bench would have both 0.

3) (LastName, Season) is not a valid candidate key because 2 players could potentially have the same last name but a different first name. Also this combination would make it that players can not have same last names and play in the same season.

4) This is is not a valid candidate key because it does not container the minimal number of attributes for uniquess. In fact, this contains the candidate key that was specified.

Problem 4

1) Route Number by itself is a candidate key. Another one would be (Origin, Departure, Destination, Arrival) since the assumption can be made that 2 trains cannot have the same departure and arrival times, since that would be inefficient. So this means that 2 trains have no reason to leave from the same place at the same time.

2) RouteNumber would be a primary key.

3) This not a candidate key because it contains a candidate key which is RouteNumber.

4) (Origin, Destination) is not a candidate key because this stops 2 trains that are connecting cities but going and arriving at different times.

5) This is not a candidate key because 2 trains can depart from the same place, be the same type and also have the same number of stops.

Problem 5

1) If the assumptions that no 2 legislators have the same full name, email address, phone number or web address then:

- (FirstName, MiddleName, LastName, Birthday)
- (State, Chamber, District, StartYear, EndYear)
- (State, Chamber, FirstName, MiddleName, LastName)
- (State, Chamber, District, FirstName, LastName)
- (Email) - this is assuming that each legislator has a unique email address

2) A Primary key for this table would be (State, Chamber, District, StartYear, EndYear) since this would remain unique over time of the legislator's term.

3) (Email, Phone, Web) is not a valid candidate key because these attributes could be shared by multiple people. For example, multiple can have similar website URLs or phone numbers.

4) This is not a valid candidate key because legislators in the same state can server during the same term.

5) This is not a valid candidate key because multiple legislators with the same name can server each year.

6) Not valid because legislators can share the same number and be part of the same chamber and term.