Recap of Previous Lecture

Topic — Classification of schedule based on recoverability

Topic — Irrecoverable schedule

Topic — Recoverable schedule
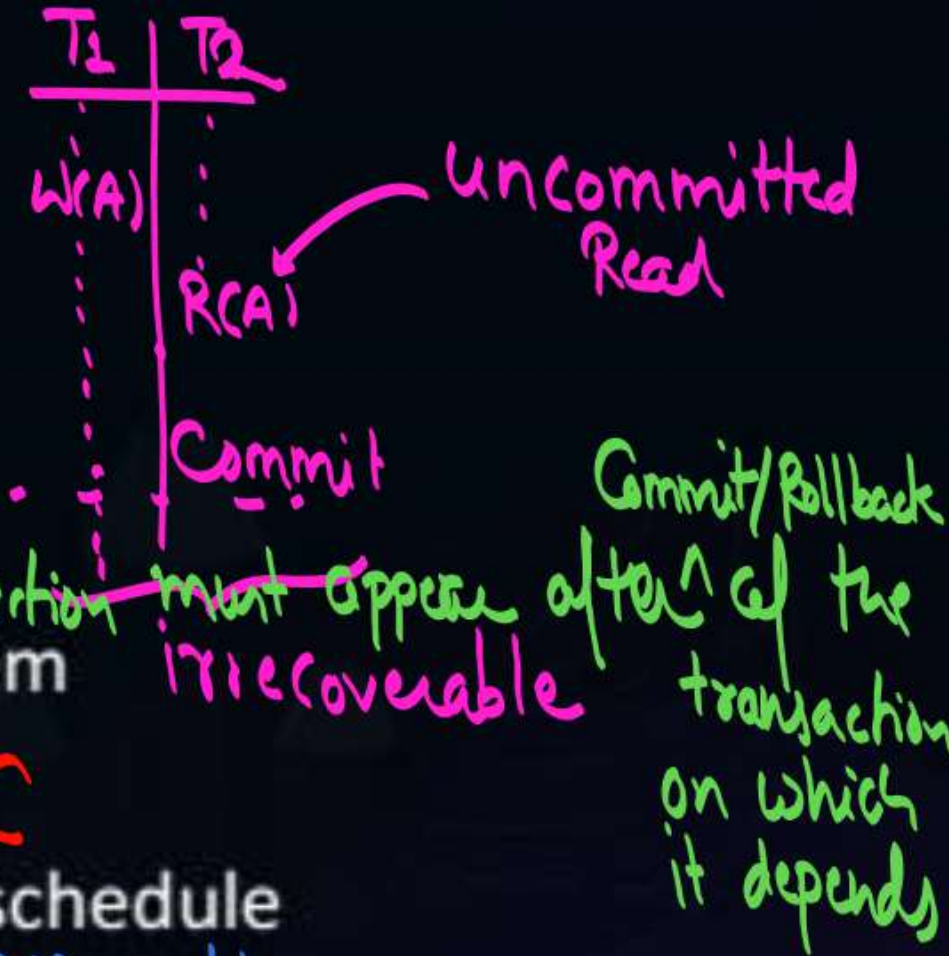- ① No uncommitted Read (or)
- ② if exist then commit of dep. transaction must appear after of the transaction on which it depends

Topic — Cascading rollback problem
- if uncommitted Read exist then Cascading rollback problem exist

Topic — Cascadeless recoverable schedule
- for Schedule to be Cascadeless recoverable there should not be any uncommitted Read op^n

Topic — Strict recoverable schedule
- Cascadeless + No lost update ⇒

T_1	T_2
$W(A)$	
	$R(A)$
	Commit

uncommitted Read

Commit/Rollback — Irrecoverable

T_1	T_2
$W(A)$	
Commit/Rollback	$R(A)/W(A)$
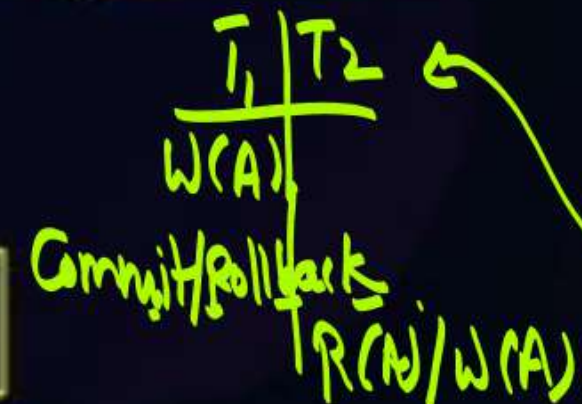
Topics to be Covered

Topic — Classification based on serializability

Topic — Conflicting and non-conflicting operations
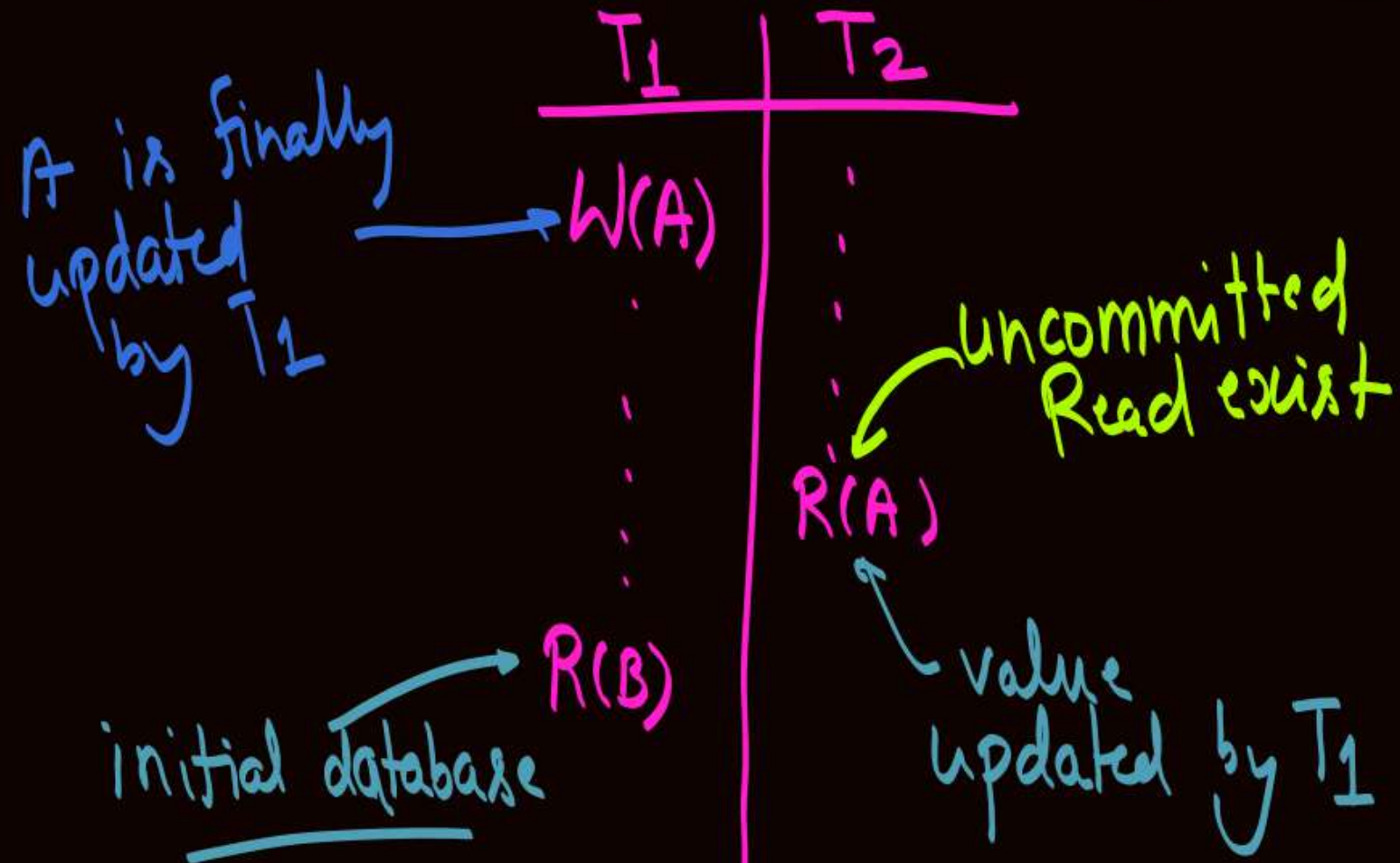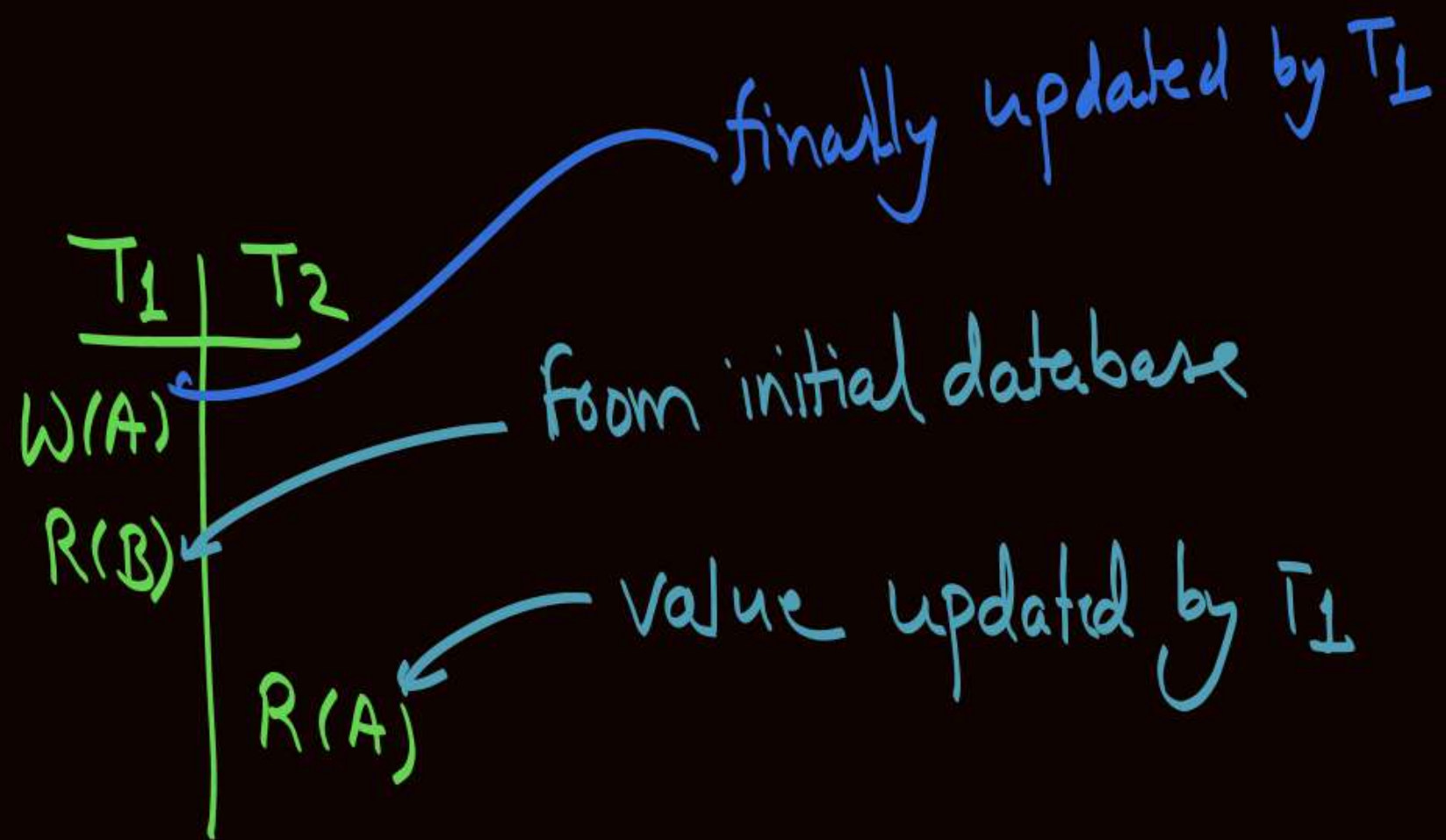
Topic — Conflict serializable schedule

Topic — Practice questions on Conflict serializable schedule

Slide

$$S \equiv T_1 \rightarrow T_2$$

T_1	T_2
W(A)	
	R(A)
R(B)	

A is finally updated by T_1

uncommitted Read exist

value updated by T_1

initial database

if T_1 fails then T_2 also need to rollback ∴ Cascading.

T_1	T_2
W(A)	
R(B)	
	R(A)

finally updated by T_1

from initial database

value updated by T_1

Based on Serializability

① Conflict Serializable Schedule

② View Serializable Schedule

Based on Recoverability
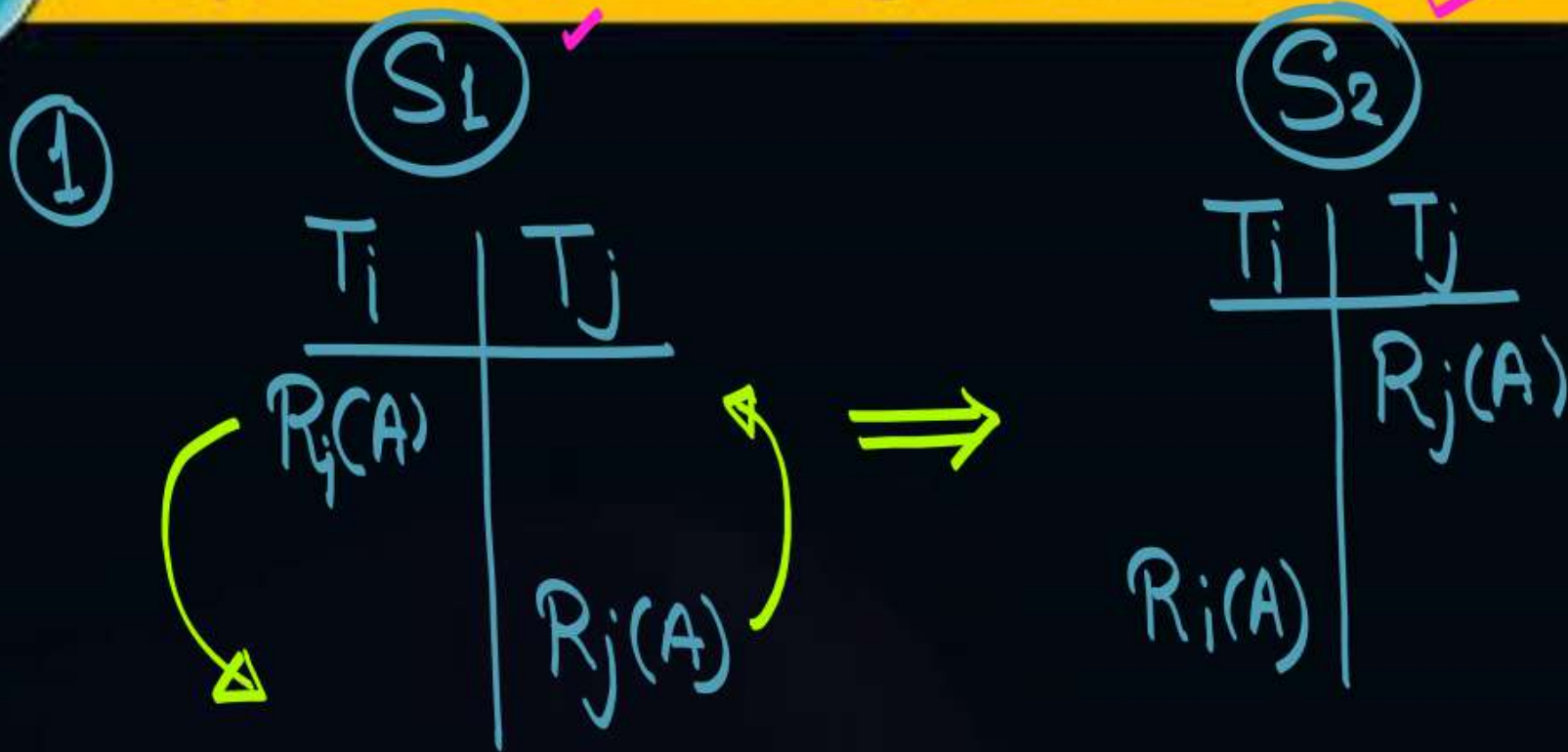
① Irrecoverable

② Recoverable

③ Cascadeless Recoverable

④ Strict Recoverable

Already done

① Conflict Serializable Schedule

(1)

(S₁)

Ti	Tj
$R_i(A)$	
	$R_j(A)$

$\Rightarrow$

(S₂)

Ti	Tj
	$R_j(A)$
$R_i(A)$	

$S_1 \equiv S_2$

Even after swapping the position of $R_i(A)$ & $R_j(A)$ the behaviour of Schedule remains same
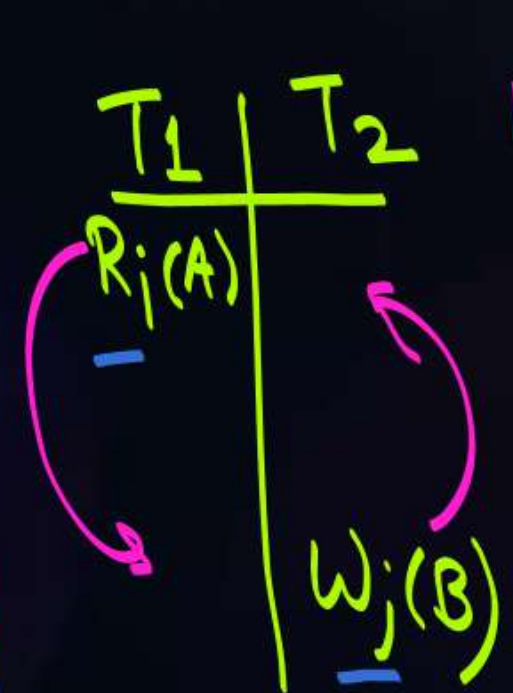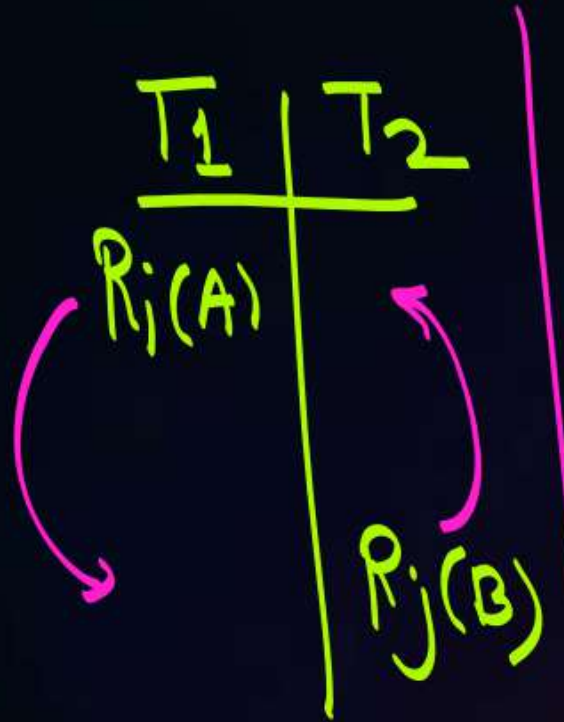
∴ $R_i(A)$ & $R_j(A)$ are non-conflicting operation

②

(S_1)

$$\begin{array}{c|c} T_i & T_j \\ \hline R_i(A)/W_i(A) & \\ & R_j(B)/W_j(B) \end{array}$$

$\Rightarrow$

(S_2)

$$\begin{array}{c|c} T_i & T_j \\ \hline & R_j(B)/W_j(B) \\ R_i(A)/W_i(A) & \end{array}$$

$S_1 \equiv S_2$

$$\begin{array}{c|c} T_1 & T_2 \\ \hline R_i(A) & \\ & R_j(B) \end{array}$$

$$\begin{array}{c|c} T_1 & T_2 \\ \hline R_i(A) & \\ & W_j(B) \end{array}$$

$$\begin{array}{c|c} T_1 & T_2 \\ \hline W_i(A) & \\ & R_j(B) \end{array}$$

$$\begin{array}{c|c} T_1 & T_2 \\ \hline W_i(A) & \\ & W_j(B) \end{array}$$
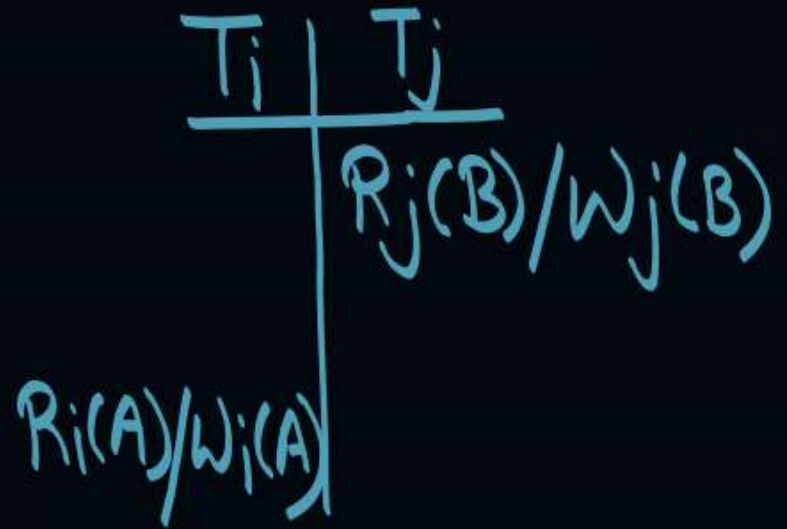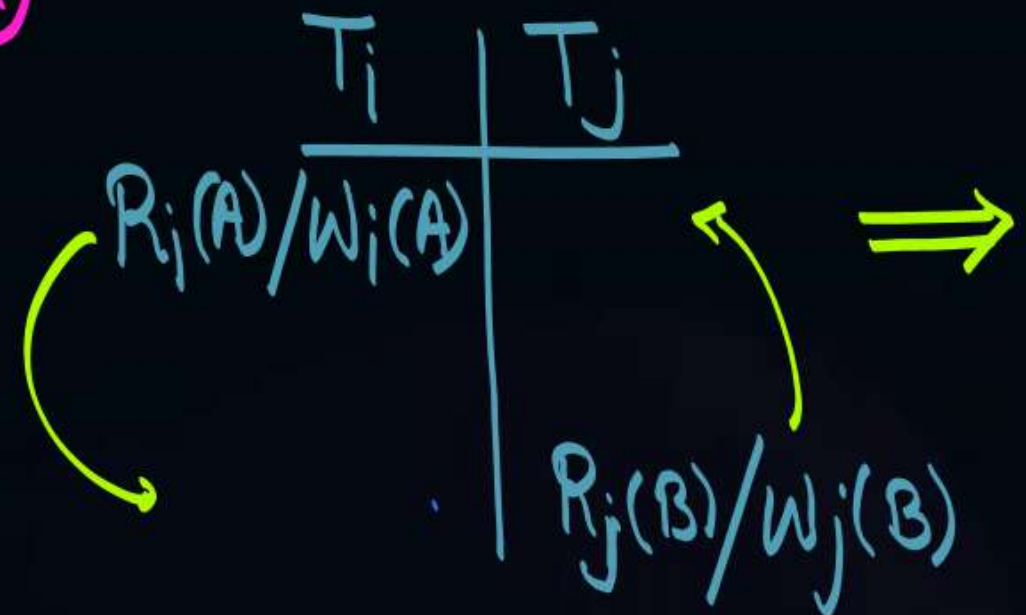
∴ $R_i(A)/W_i(A)$ &
$R_j(B)/W_j(B)$ are

non Conflicting op^n

i.e. if data items
are different then
operation are
non-Conflicting

③

S_1

T_i	T_j
$R_i(A)$	
	$W_j(A)$

$\Rightarrow$

S_2

T_i	T_j
	$W_j(A)$
$R_i(A)$	
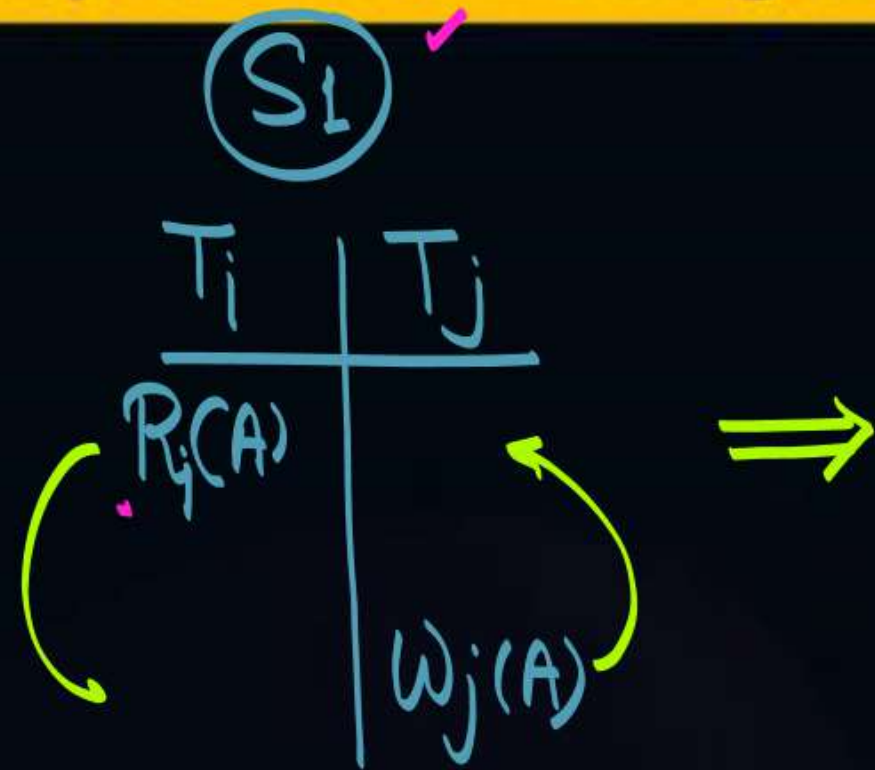
$S_1 \neq S_2$

$\underbrace{\qquad}$
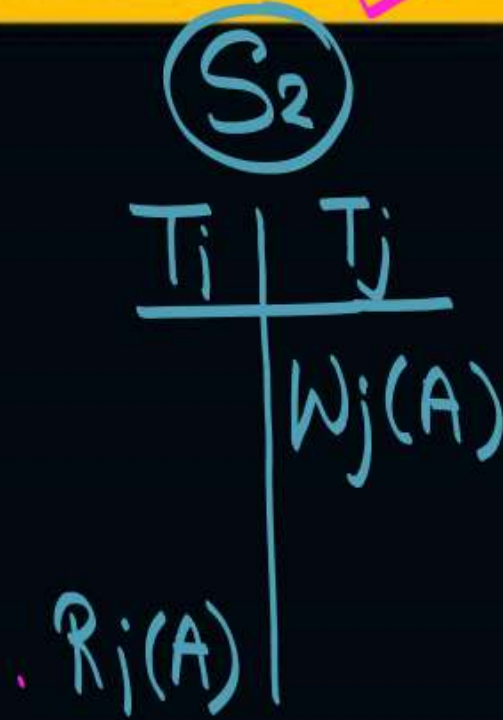
$\rightarrow R_i(A) \,\&\, W_j(A)$ are Conflicting op^n

Similarly

S_1

T_i	T_j
$W_i(A)$	
	$R_j(A)$

$\Rightarrow$

S_2

T_i	T_j
	$R_j(A)$
$W_i(A)$	
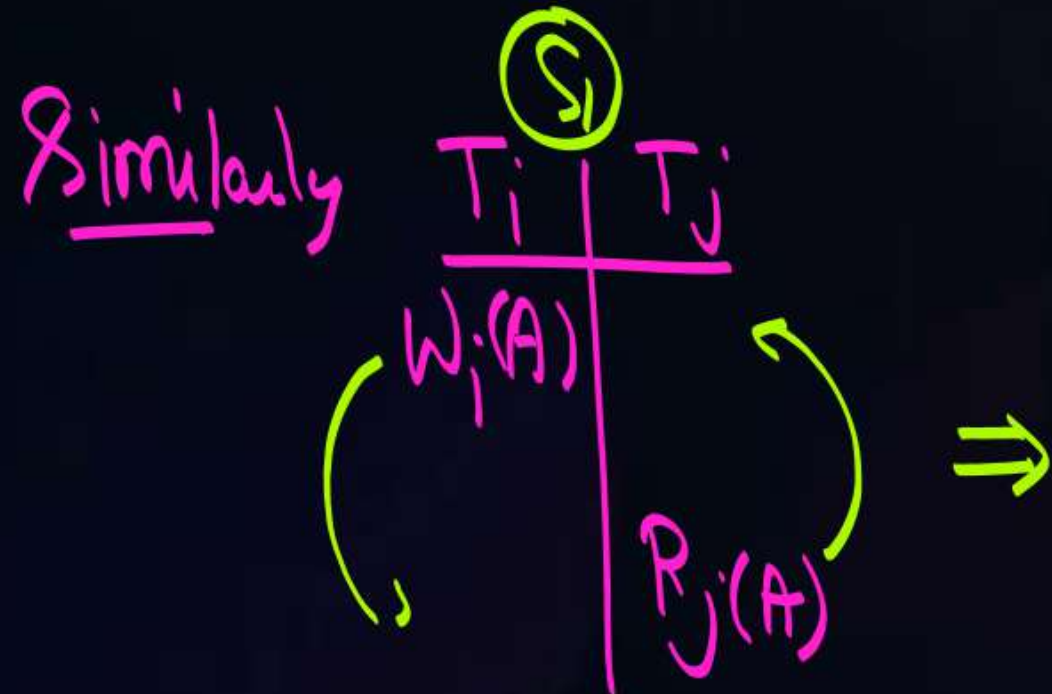
Similarly

$S_1 \neq S_2$

$\underbrace{\qquad} \rightarrow W_i(A) \,\&\, R_j(A)$ are Conflicting operation

④

S_1

T_i	T_j
$W_i(A)$	
	$W_j(A)$

$\Rightarrow$

S_2

T_i	T_j
	$W_j(A)$
$W_i(A)$	
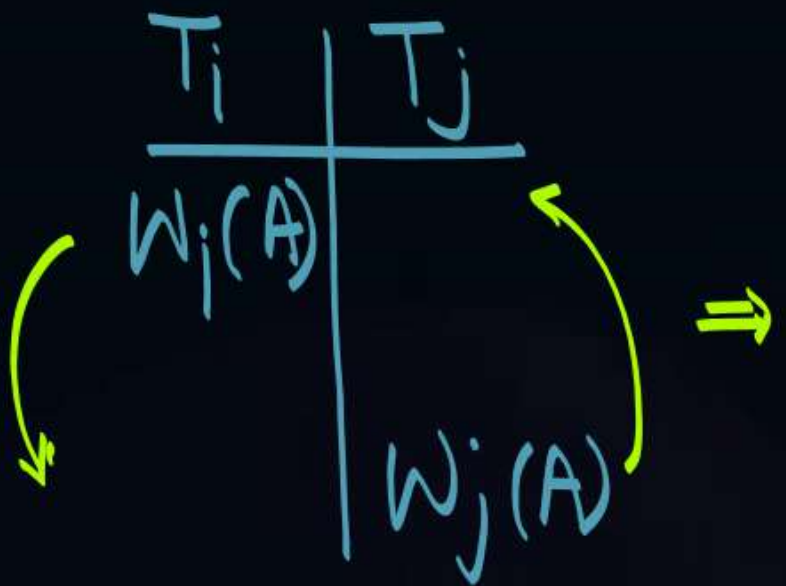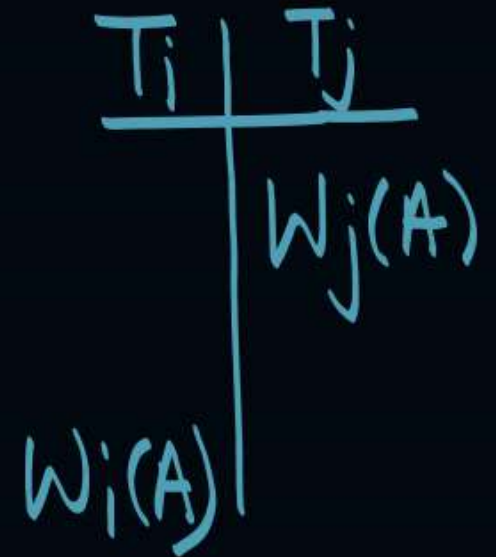
$S_1 \neq S_2$

$\therefore W_i(A) \,\&\, W_j(A)$ are Conflicting op^n

Conflicting Operations : Two operations are called as conflicting operations if all the following conditions hold true for them -

☐ Both the operations belong to different transactions

☐ Both the operations are on the same data item

☐ At least one of the two operations is a write operation

Non-Conflicting Operations : Two operations are non-conflicting

operations if and only if

☑ ❑ Both the operations are on different data items

or

☑ ❑ Both the operations are read operations

Consider two schedules Si and Sj,

If one of them can be transformed into another by swapping the position of any number of the non-conflicting operations in it then schedule Si and Sj are called conflict equivalent schedule.

eg:

S_1

T_1	T_2
$R_1(A)$	
$W_1(A)$	
	$R_2(A)$
	$R_2(B)$
$R_1(B)$	
$W_1(B)$	

S_2

T_1	T_2
$R_1(A)$	
$W_1(A)$	
	$R_2(A)$
$R_1(B)$	
	$R_2(B)$
$W_1(B)$	
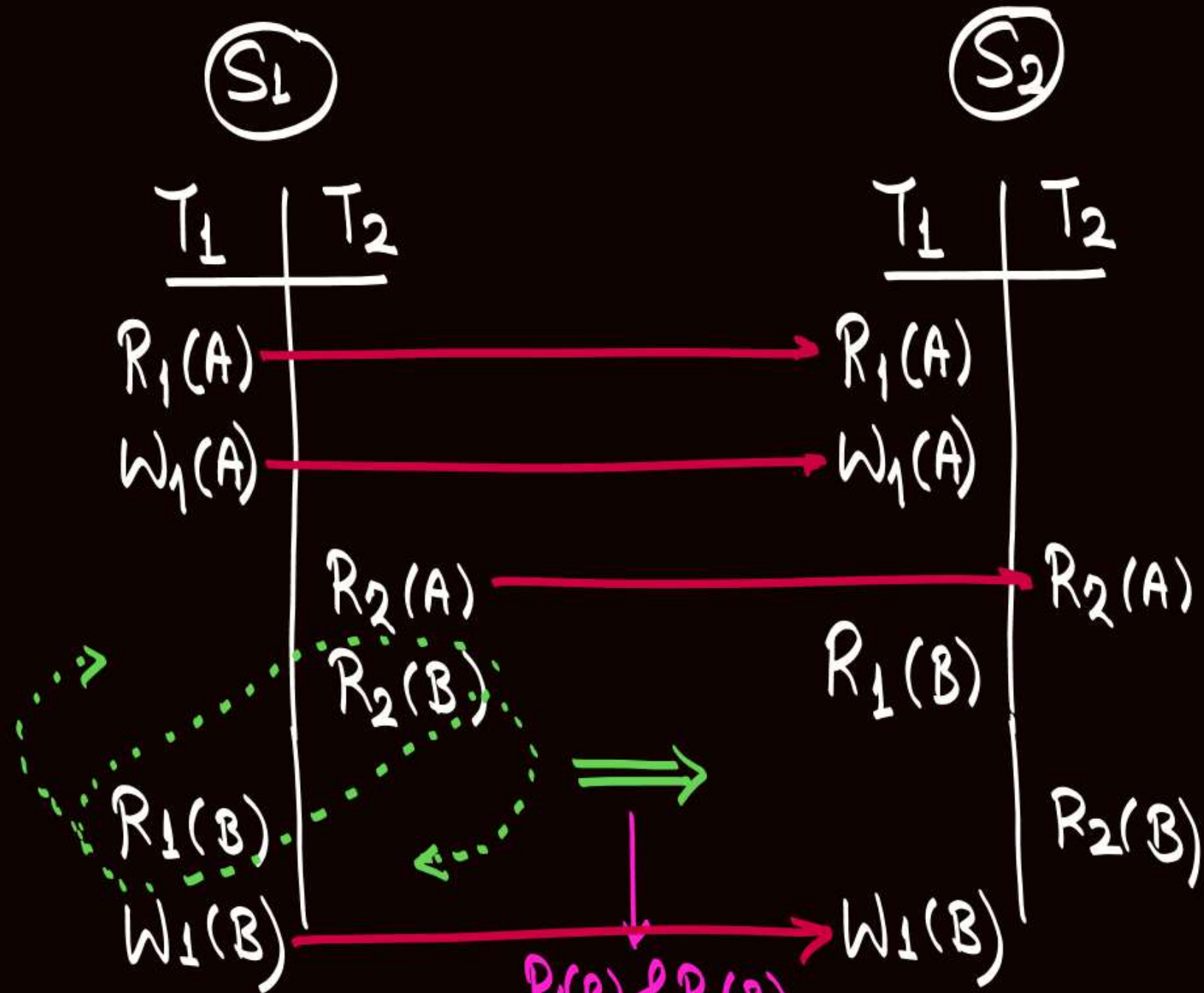
$R_1(B) \& R_2(B)$
are non-Conflicting op^n

∴ Their Position Can be Swapped

Hence S_1 is Conflict Equivalent to S_2

Is S_1 equal to S_2

Ans = No

$S_1 \neq S_2$

but $S_1 \equiv S_2$

Schedules are not same, only their behaviour is same

eg:

S_1

T_1	T_2
$R_1(A)$	
$W_1(A)$	
	$R_2(A)$
	$R_2(B)$
$R_1(B)$	
$W_1(B)$	

Non-Conflicting

S_2

T_1	T_2
$R_1(A)$	
$W_1(A)$	
$R_1(B)$	
	$R_2(B)$
	$R_2(A)$
$W_1(B)$	

transaction T_2 itself has changed

$\downarrow$

We can not swap operations like this

$\therefore$ No point of schedule being Equivalent or Non-Equivalent

e.g.

S_1

T_1	T_2
$R_L(A)$	
$W_1(A)$	
	$R_2(A)$
$R_1(B)$	
$W_1(B)$	
	$R_2(B)$

$R_2(A)$ is non-Conflicting with both $R_1(B)$ as Well as $W_1(B)$

∴ we Can Swap

↳ Hence S_1 & S_2 are Conflict Equivalent

S'

T_1	T_2
$R_L(A)$	
$W_1(A)$	
$R_1(B)$	
	$R_2(A)$
$W_1(B)$	
	$R_2(B)$

$S_1 \equiv S'$ & $S' \equiv S_2$ ∴ $S_1 \equiv S_2$

$S_2 = T_1 \rightarrow T_2$

T_1	T_2
$R_L(A)$	
$W_1(A)$	
$R_1(B)$	
$W_1(B)$	
	$R_2(A)$
	$R_2(B)$

$$\boxed{S_1}$$

$$T_1 \mid T_2 \mid T_3$$

Serial Schedule
$$(T_2 \rightarrow T_1 \rightarrow T_3)$$

$\boxed{S_1}$ is Conflict equivalent to $T_2 \rightarrow T_1 \rightarrow T_3$

$$S_1 \equiv T_2 \rightarrow T_1 \rightarrow T_3$$

$\therefore$ S_1 is Serializable Schedule

If given schedule can be converted into a serial schedule by swapping the positions of any no. of its non-conflicting operations, then it is called a conflict serializable schedule.

If given schedule is conflict equivalent to at least one of the serial schedule, then it is called a conflict serializable schedule.

Q: Check whether the given schedule 'S' is a Conflict Serializable schedule or not?

$T_1 \rightarrow T_2$

T_1	T_2
$R_1(A)$	
$W_1(A)$	
$R_1(B)$	
$W_1(B)$	
	$R_2(A)$
	$R_2(B)$

Ⓢ

T_1	T_2
$R_1(A)$	
$W_1(A)$	
	$R_2(A)$
	$R_2(B)$
$R_1(B)$	
$W_1(B)$	

$W_1(A)$ & $R_2(A)$ are Conflicting operations

∴ $R_2(A)$ Can not be moved above $W_1(A)$

∴ Schedule S can not be Conflict Equivalent to Serial Schedule $T_2 \rightarrow T_1$

$R_2(B)$ & $W_1(B)$ are Conflicting operations, ∴ $R_2(B)$ Can not be moved below $W_1(B)$, ∴ Schedule S Can not be Conflict Equivalent to Serial Schedule $T_1 \rightarrow T_2$

$T_2 \rightarrow T_1$

T_1	T_2
	$R_2(A)$
	$R_2(B)$
$R(A)$	
$W_1(A)$	
$R_1(B)$	
$W_1(B)$	

Schedule 'S' is not Conflict Equivalent to any of the serial schedule,

Hence, Schedule 'S' is not a Conflict Serializable schedule

Q: Check whether the given schedule 'S' is a Conflict serializable schedule or not.

⑤

T_1	T_2
	$R_2(A)$
$R_1(A)$	
$W_1(A)$	
	$R_2(B)$
$R_1(B)$	
$W_1(B)$	

$R_2(A)$ & $W_1(A)$ are Conflicting operation

∴ $R_2(A)$ can not be moved below $W_1(A)$

∴ Schedule S Can not be Conflict Equivalent to Serial Schedule $T_1 \rightarrow T_2$

$T_1 \rightarrow T_2$

$T_1 \quad T_2$

T_1	T_2
$R_1(A)$	
$W_1(A)$	
$R_1(B)$	
$W_1(B)$	
	$R_2(A)$
	$R_2(B)$

④

$4! = 24$

Q: Check whether the given schedule 'S' is a Conflict serializable Schedule or not.

$T_2 \rightarrow T_1$

Ⓢ

T_1	T_2
	$R_2(A)$
$R_1(A)$	
$W_1(A)$	
	$R_2(B)$
$R_1(B)$	
$W_1(B)$	

Non-conflicting ∴ we can swap their position ⟹

T_1	T_2
	$R_2(A)$
	$R_2(B)$
$R_1(A)$	
$W_1(A)$	
$R_1(B)$	
$W_1(B)$	

S is Conflict Equivalent to serial Schedule $T_2 \rightarrow T_1$

* S is not Conflict Equivalent to serial schedule $T_1 \rightarrow T_2$

· S is Conflict Equivalent to serial schedule $T_2 \rightarrow T_1$

⌐ S is Conflict equivalent to at least one of the serial schedule.

∴ S is Conflict serializable schedule

⌐ S is Conflict equivalent to serial schedule $T_2 \rightarrow T_1$

∴ Conflict equivalent serial schedule is $T_2 \rightarrow T_1$

Note:- ① If given schedule is a Conflict Serializable Schedule then we are sure that the given Schedule is a Serializable Schedule.

② If given schedule is not a Conflict serializable Schedule, then the given Schedule may or may not be serializable.

i.e. even Non-Conflict Serializable Schedule Can also be a Serializable Schedule

↳ If the only information available is that the Schedule is not a Conflict Serializable Schedule, then we can not Say that the Schedule is a non-Serializable Schedule

* Position of Conflicting operations of two transactions will define the precedence order in which transactions must execute in any Conflict equivalent serial schedule.

eg.

(S)
$T_i \quad T_j$

$R_i(A)$

$W_j(A)$

Predence is

$T_i \xrightarrow[then]{} T_j$
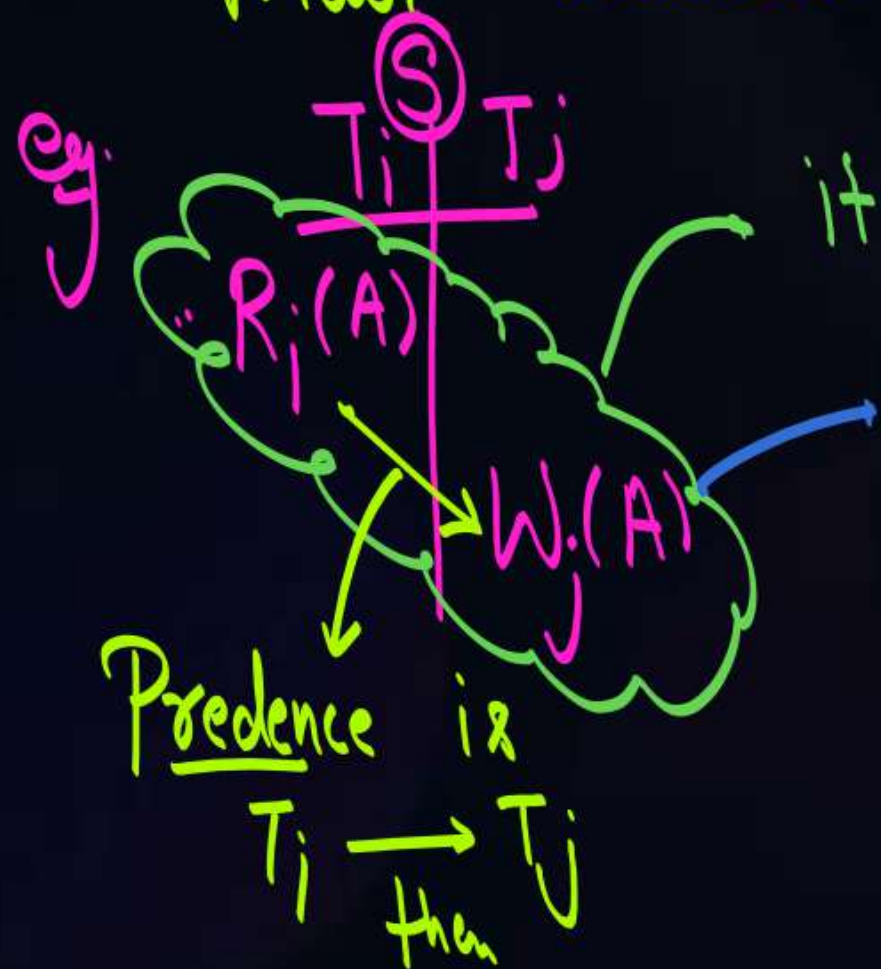
it is a pair of Conflicting operations in any serial schedule which is conflict equivalent to schedule 'S', execution of T_i must happen before execution of T_j
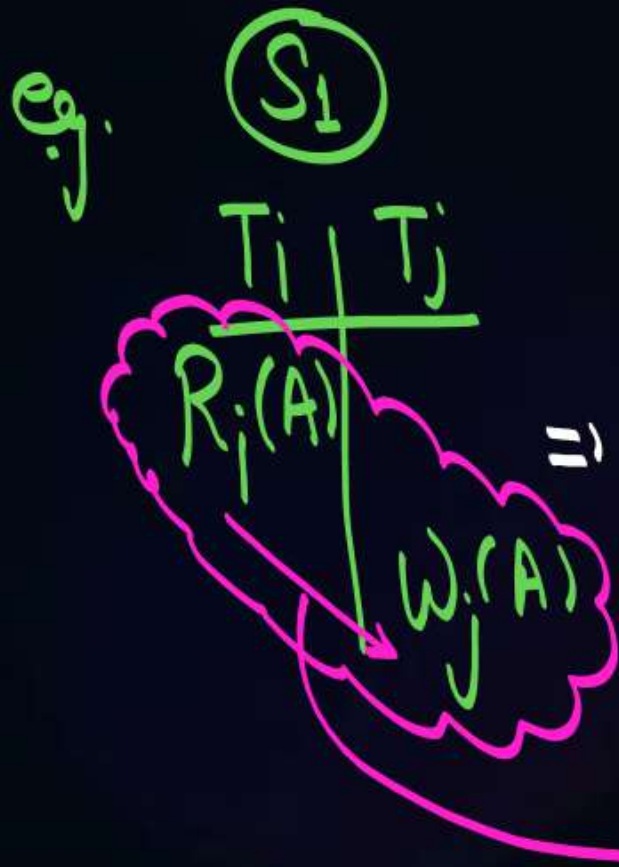
Precedence graph $G = (V, E)$ is a directed graph,

Where

$V =$ Set of all transaction of given schedule

$E =$ Set of directed edges based on Precedence defined by Conflicting operation of given schedule

eg. $\boxed{S_1}$

T_i	T_j
$R_i(A)$	
	$W_j(A)$

$\Rightarrow$

Precedence graph for S_1

$T_i \longrightarrow T_j$

eg

S_2

T_1	T_2
$R_1(A)$	
	$W_2(A)$
$W_1(A)$	

Precedence graph
of S_2

e.g.

S_3

T_1	T_2	T_3
$R_1(A)$		
	$R_2(B)$	
$W_1(B)$		
		$W_3(A)$
	$R_2(C)$	
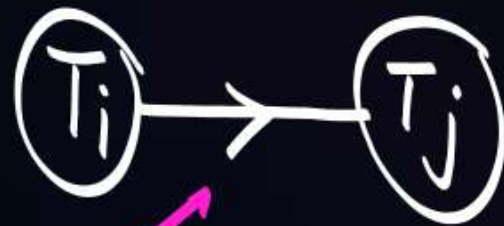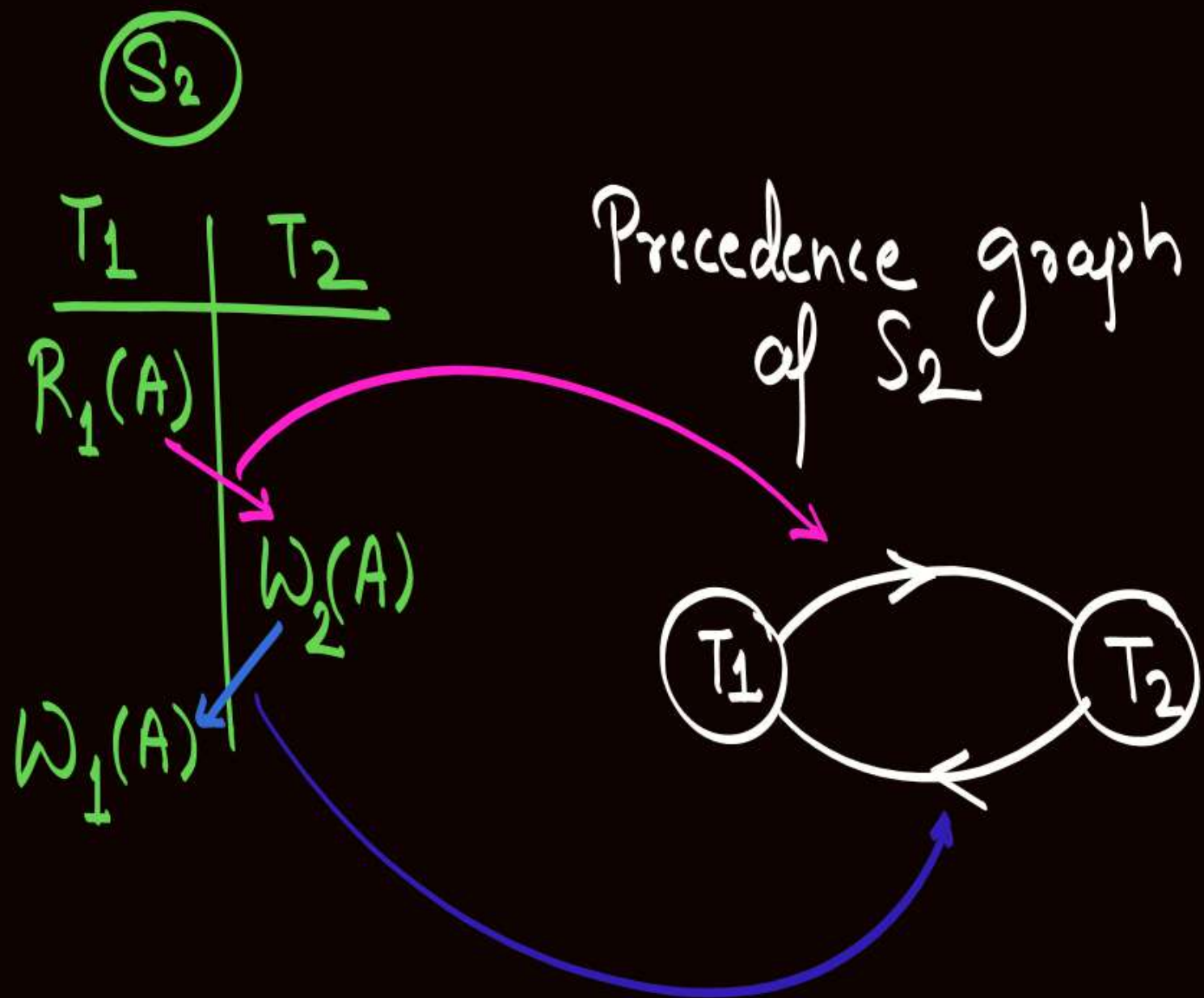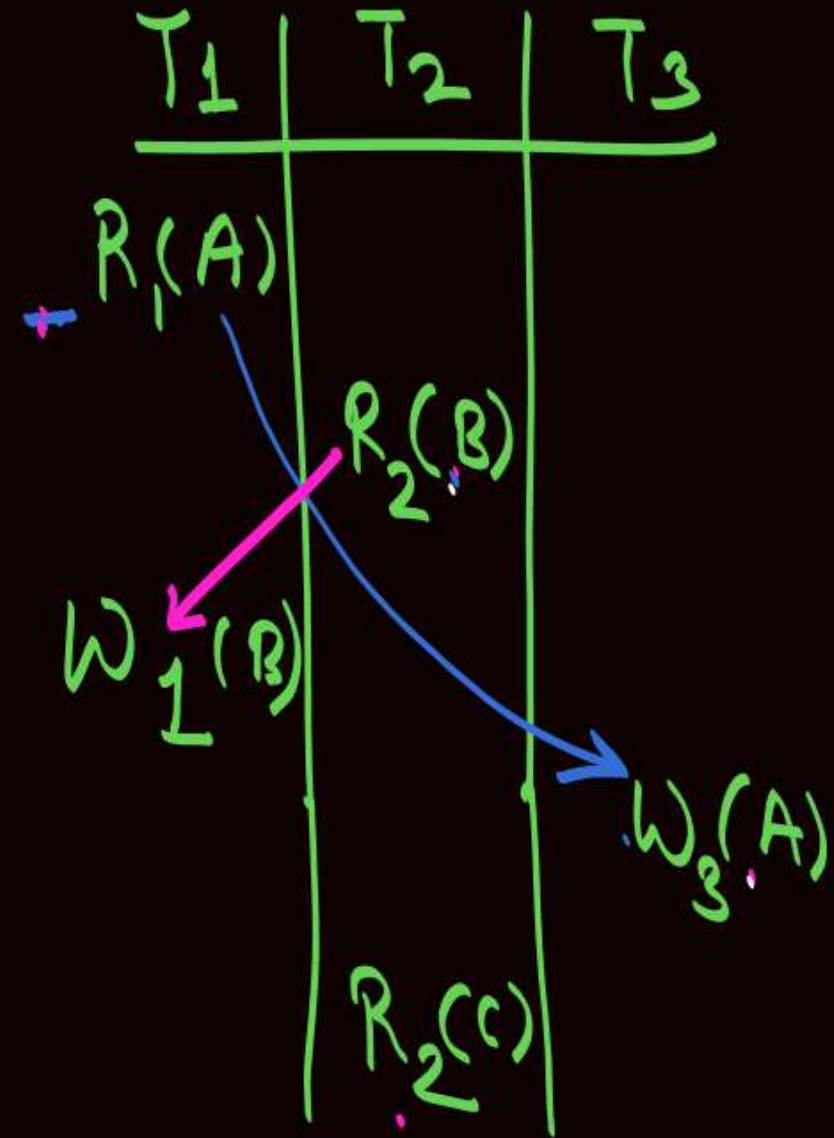
Precedence graph for S_3

eg.

S_4
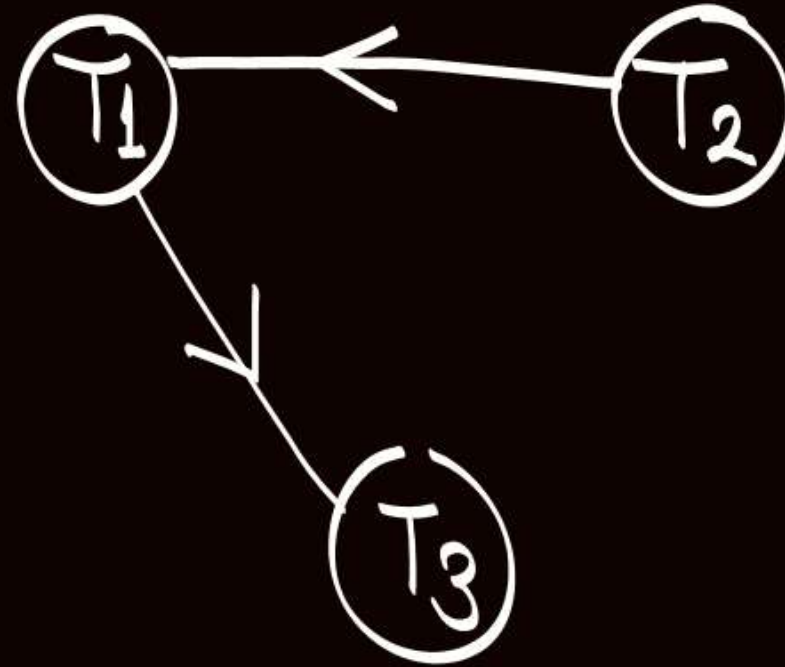
T_1	T_2
$R_1(A)$	
	$W_2(B)$

Precedence graph
for S_4

T_1 T_2

No Conflicting Op^n b/w T_1 & T_2
∴ No edge b/w T_1 & T_2

Home Work:

Draw the Precedence graph for all the Schedules Specified in the upcoming Slides.

Note:- Just draw precedence graph, Don't try to solve Complete question

#Q. Check whether the schedule is conflict serializable schedule or not? If conflict serializable schedule then identify all conflict equivalent serial schedules.

T_1	T_2	T_3
		$R_3(x)$
		$R_3(z)$
$R_1(x)$		
$W_1(x)$		
		$W_3(y)$
		$W_3(x)$
	$R_2(x)$	
$R_1(y)$		
$W_1(y)$		

#Q. Check whether the schedule is conflict serializable schedule or not?
If conflict serializable schedule then identify all conflict equivalent serial schedules.

T_1	T_2	T_3
		$R_3(y)$
		$R_3(z)$
$R_1(x)$		
$W_1(x)$		
		$W_3(y)$
		$W_3(z)$
	$R_1(z)$	
$R_1(y)$		
$W_1(y)$		
	$R_2(y)$	
	$W_2(y)$	
	$R_2(x)$	
	$W_2(x)$	

#Q. Check whether the schedule is conflict serializable schedule or not? If conflict serializable schedule then identify all conflict equivalent serial schedules.

T_1	T_2	T_3
	$R_2(A)$	
$R_1(B)$		
	$W_2(A)$	
		$R_3(A)$
$W_1(B)$		
$W_1(A)$		
	$R_2(B)$	
	$W_2(B)$	

#Q. Check whether the schedule is conflict serializable schedule or not? If conflict serializable schedule then identify all conflict equivalent serial schedules.

T_1	T_2	T_3
		$W_3(B)$
$R_1(A)$		
$W_1(B)$		
	$R_2(B)$	
	$H_2(C)$	
		$R_3(C)$

#Q. Check whether the schedule is conflict serializable schedule or not? If conflict serializable schedule then identify all conflict equivalent serial schedules.

T_1	T_2	T_3
	$R_2(z)$	
	$R_1(y)$	
	$W_2(y)$	
		$R_3(y)$
		$R_3(z)$
$R_1(x)$		
$W_1(x)$		
		$W_3(y)$
		$W_3(z)$
	$R_2(z)$	
$R_1(y)$		
$W_1(y)$		

#Q. Check whether the schedule is conflict serializable schedule or not? If conflict serializable schedule then identify all conflict equivalent serial schedules.

T_1	T_2	T_3	T_4
$R_1(A)$			
	$R_2(A)$		
		$R_3(A)$	
			$R_4(A)$
$W_1(B)$			
	$W_2(B)$		
		$W_3(B)$	

#Q. Check whether the schedule is conflict serializable schedule or not? If not conflict serializable then check where the schedule is serializable schedule or not?

T_1	T_2	T_3
$R_1(A)$		
	$W_2(A)$	
$W_1(A)$		
		$W_3(A)$

#Q. Check whether the schedule is conflict serializable schedule or not?

If not conflict serializable then check where the schedule is serializable schedule or not?

T_1	T_2	T_3
	$W_2(A)$	
$W_1(A)$		
	$W_2(A)$	
		$W_3(A)$

Topic — Classification based on serializability

Topic — Conflicting and non-conflicting operations

Topic — Conflict serializable schedule

Topic — Practice questions on Conflict serializable schedule