

# EMBEDDED SYSTEMS

Prerane

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# Syllabus

15 P System layers MAPE loop

$\frac{81}{90}$  for 1.0

15 P { BDD  
IBD  
Content

15 Petri nets

Model | Analyse

15 IA

Model | Compose | transform to SD

15 Sequence diagrams

Model | Analysis | transform to IA, FSM, IBD

15 field buses

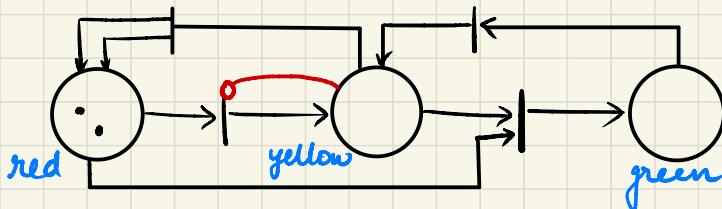
7

3 big modelling questions maybe + conversions

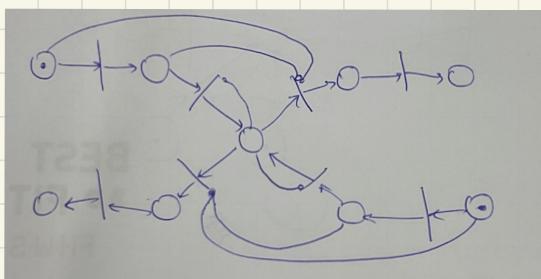
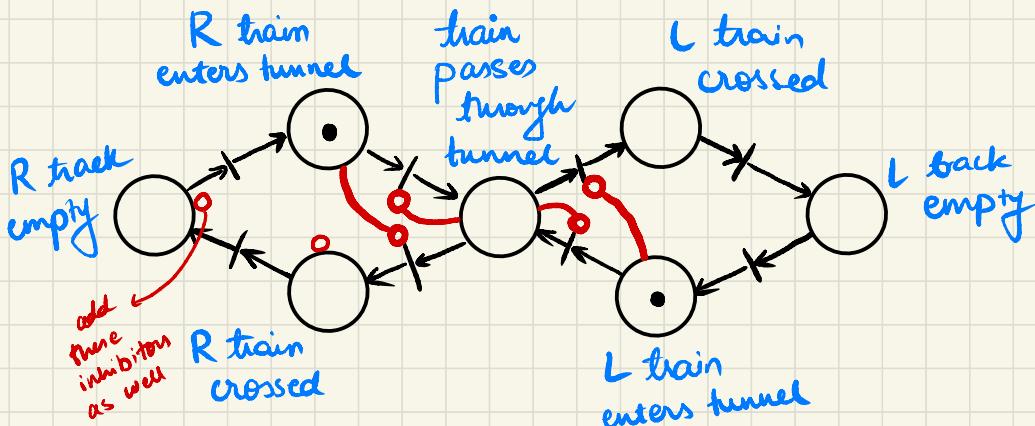
# TOPIC : PETRI NETS

## ⇒ MODELLING

Q) Model a traffic light using Petri nets



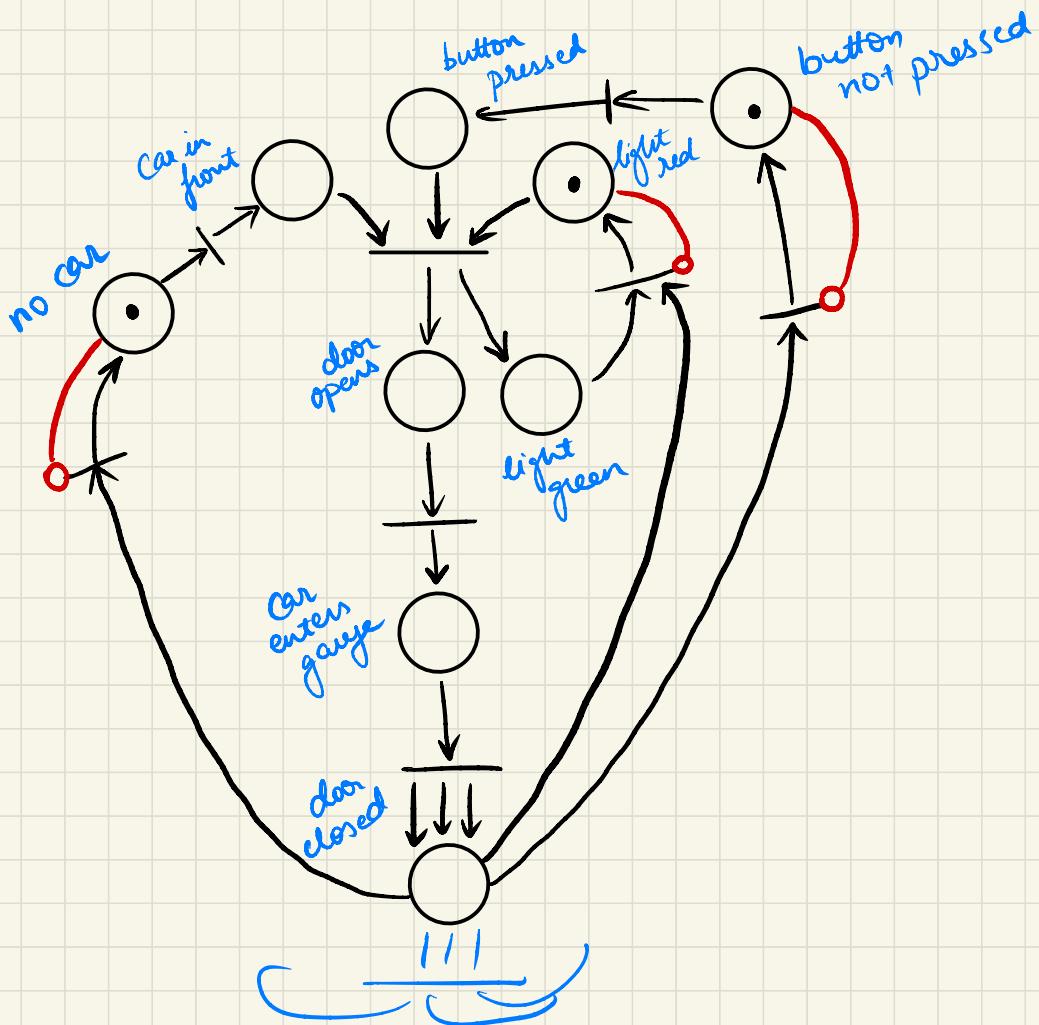
Q) Two trains can enter a tunnel but only one can pass.



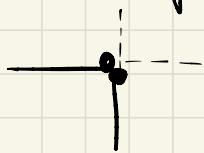
Ask doubt  
tomorrow!!

Q) Model the entering of a Car into a Garage with Petri nets.

1. Car waits in front of garage door
2. Driver pushes the button of the remote control
3. Door opens
4. When door opens, signal light switches to green.
5. The car enters garage
6. The door closes and signal light switches back to red.
7. The door is closed.

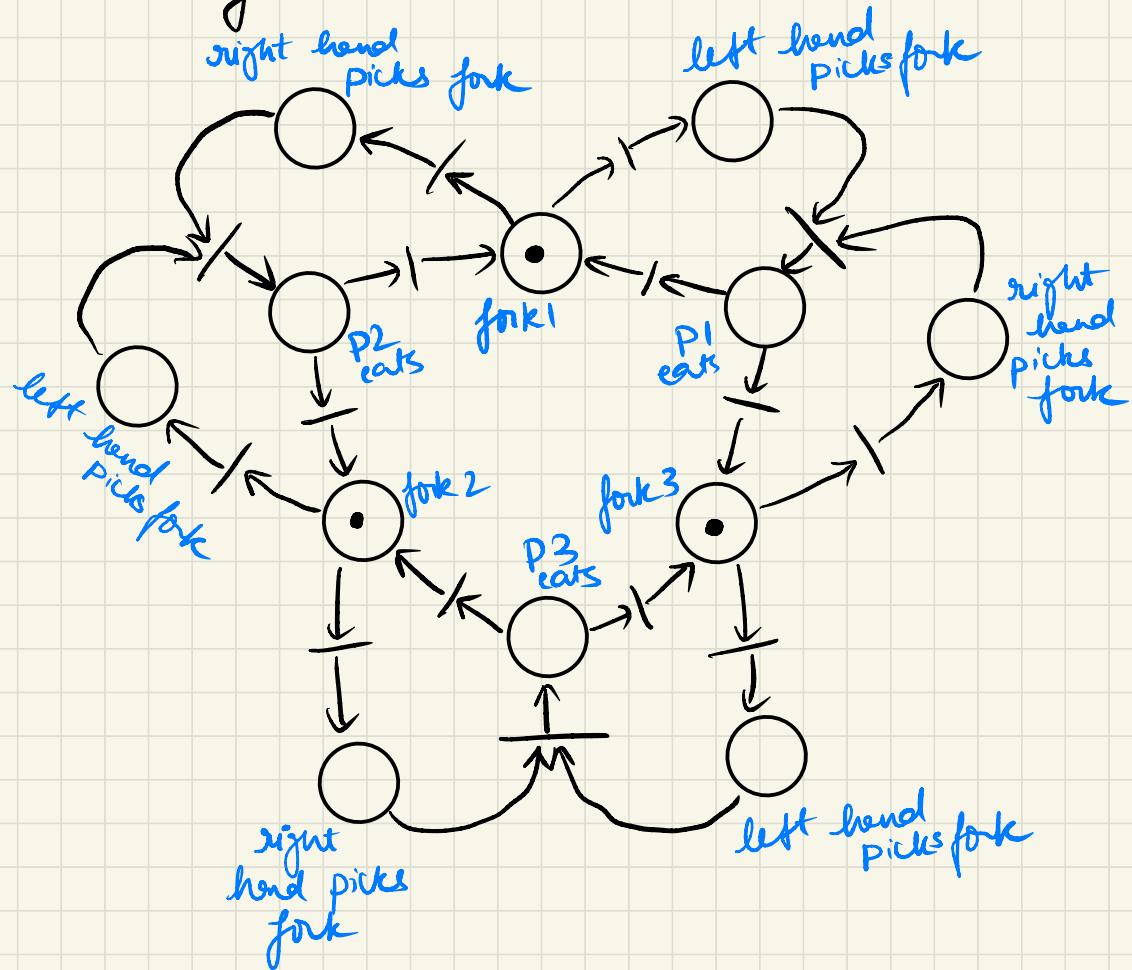


Q Model a petri net for 2 traffic lights at a junction

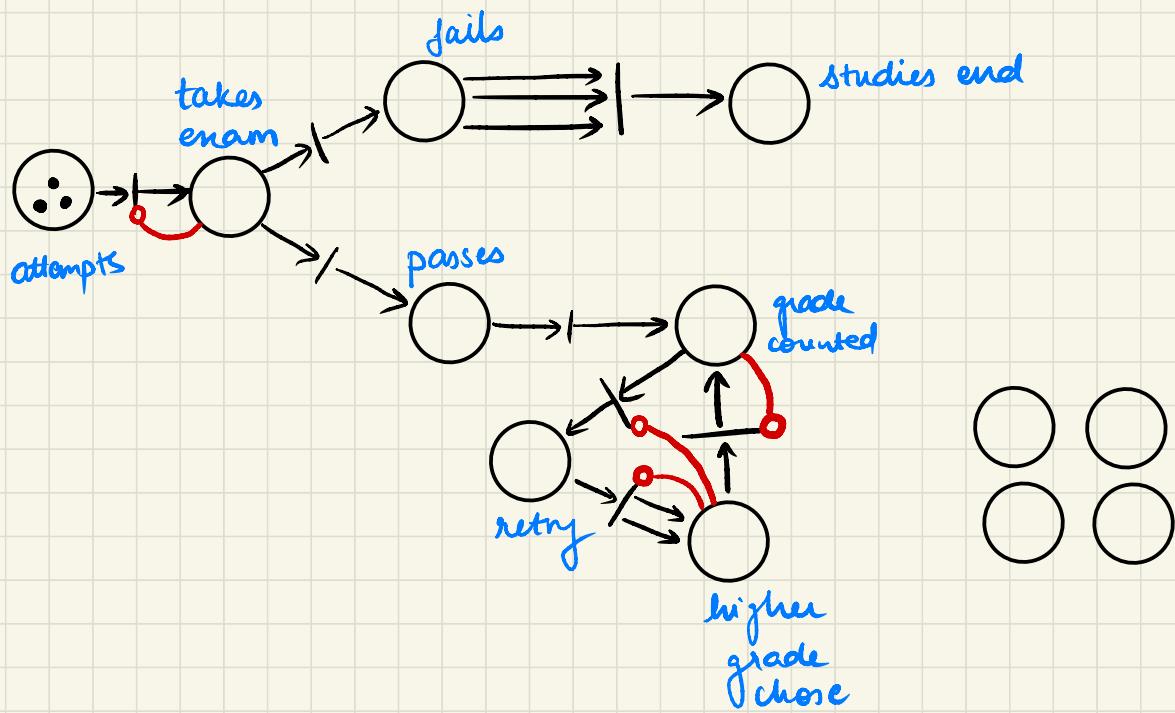


## Q) Dining Philosophers problem -

each philosopher needs 2 forks to eat. there are 3 philosophers at a table with a fork in b/w each of them

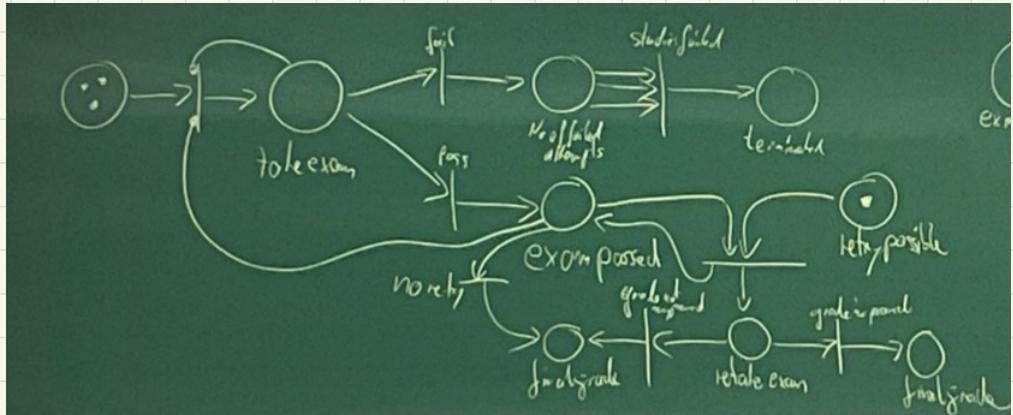


8) A student can take the very hard ES&FB exam up to 3 times. If the student passes one try, the course is passed and only one retry is permitted. In case of a retry, the best result is accounted for. If the student fails three times, the studies end.  
 Model with petri nets.



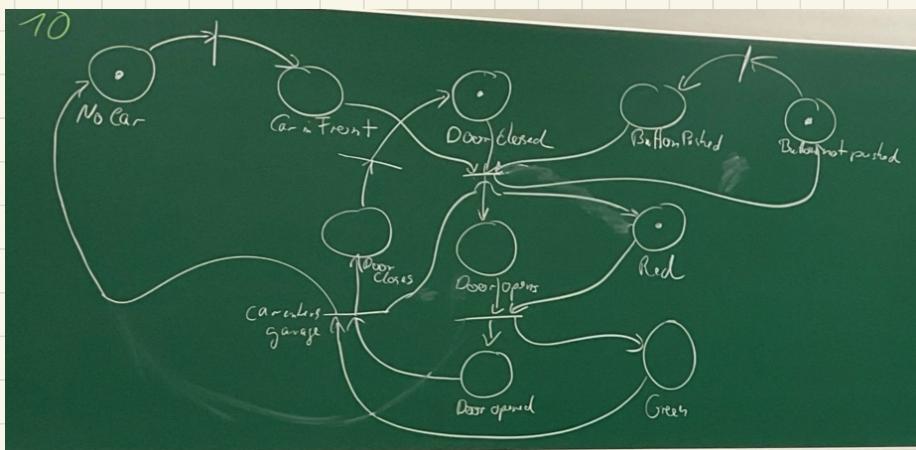
# Professor's answers

F student can take the very hard ES&FB exam, up to 3 times  
 If the student passes one try, the course is passed and only one retry is permitted.  
 In case of a retry, the best result is accounted for.  
 If the student fails three times the studies end.



Model the Entering of a Car into a Garage with Petri Nets,  
 Interface Automata, Sequence Diagrams, Internal Block Diagrams:

1. The car waits in front of the garage door
2. The driver pushes the button of the remote control
3. The door opens
4. When the door is opened, the signal light switches to green
5. The car enters the garage
6. The door closes and the signal light switches back to red
7. The door is closed

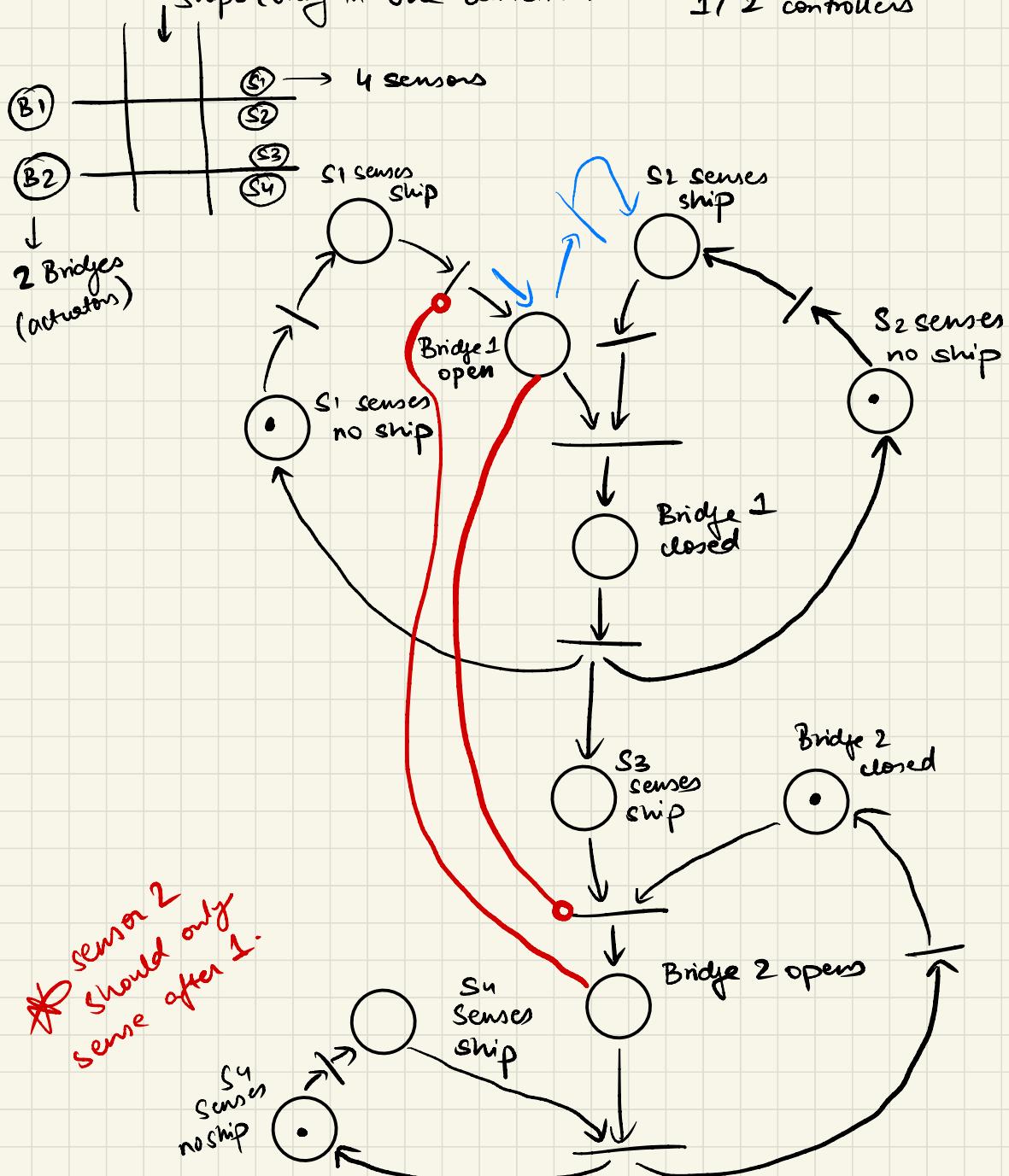


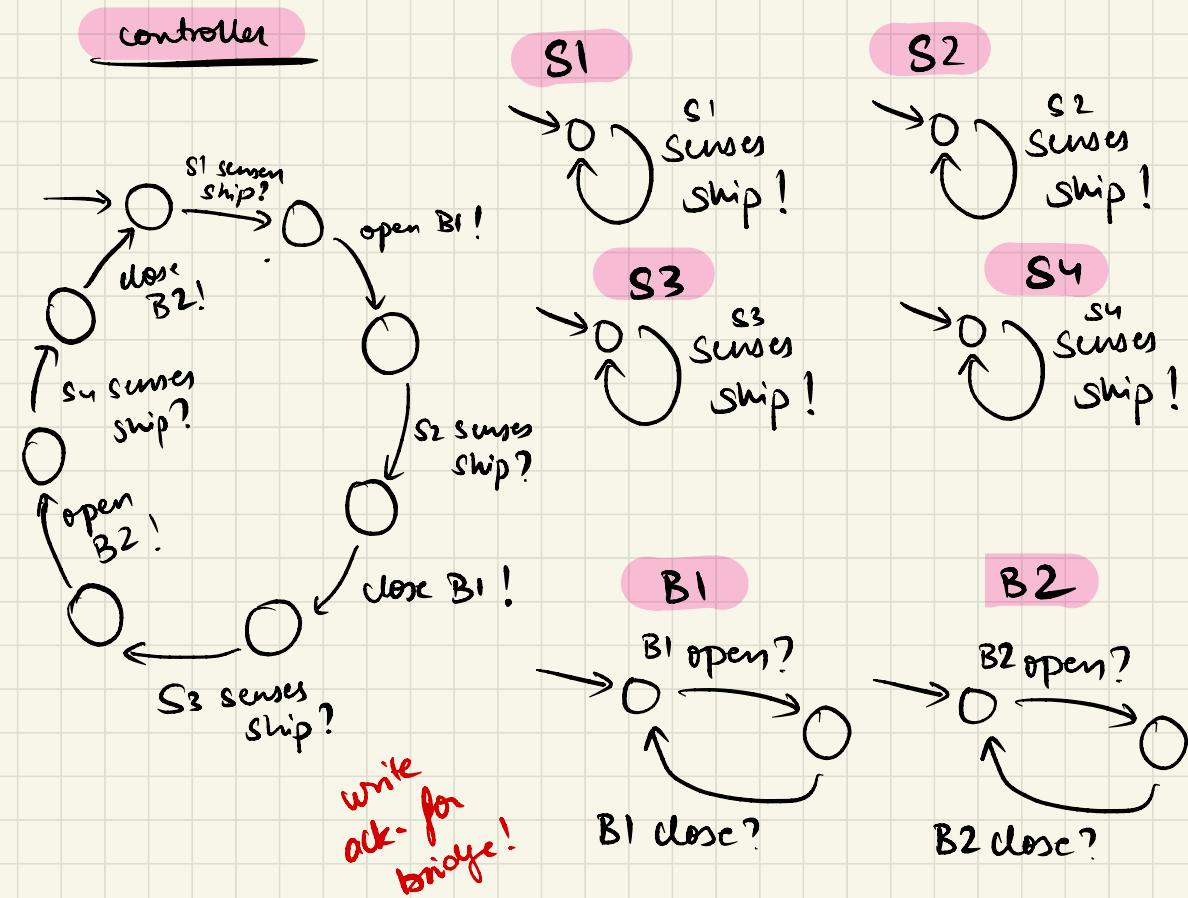
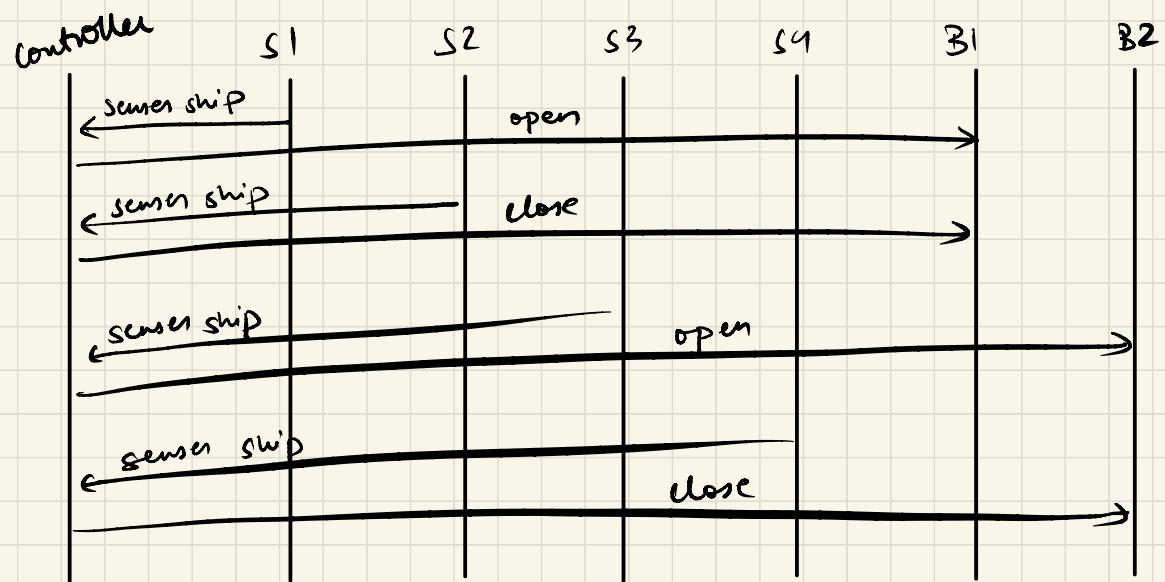
# 8 Waterway with 2 Bridges

One bridge needs to be closed at all times

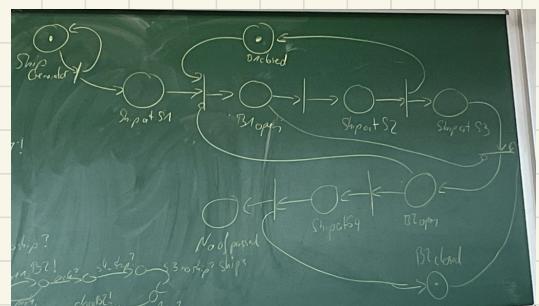
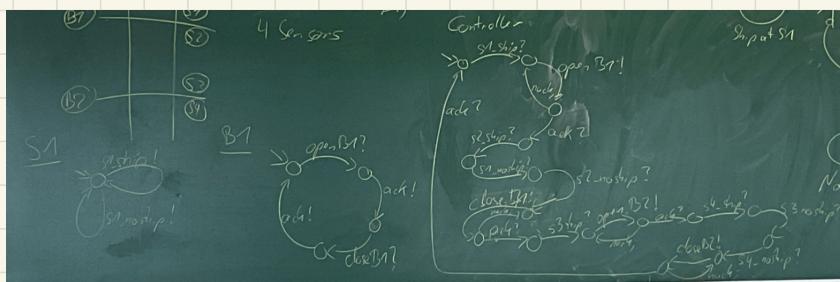
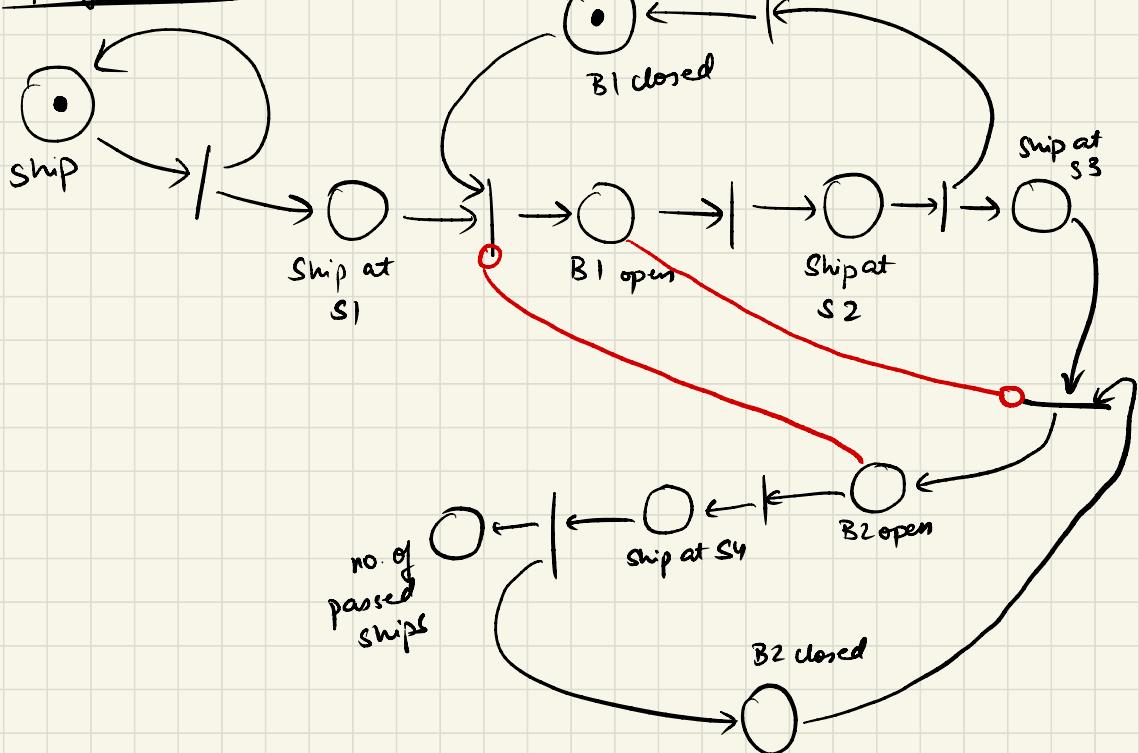
Ships (only in one direction)

1/2 controllers





prof ans.



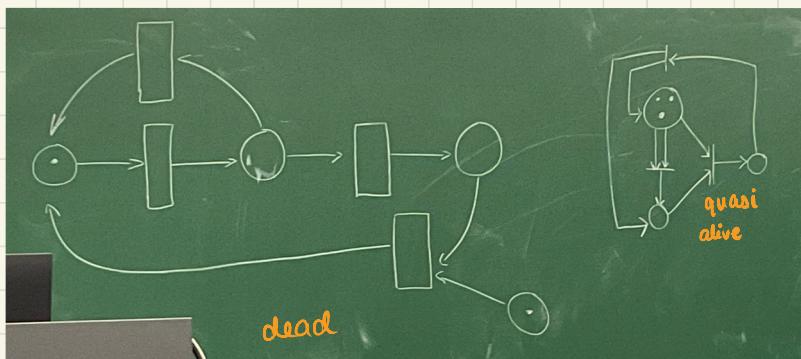
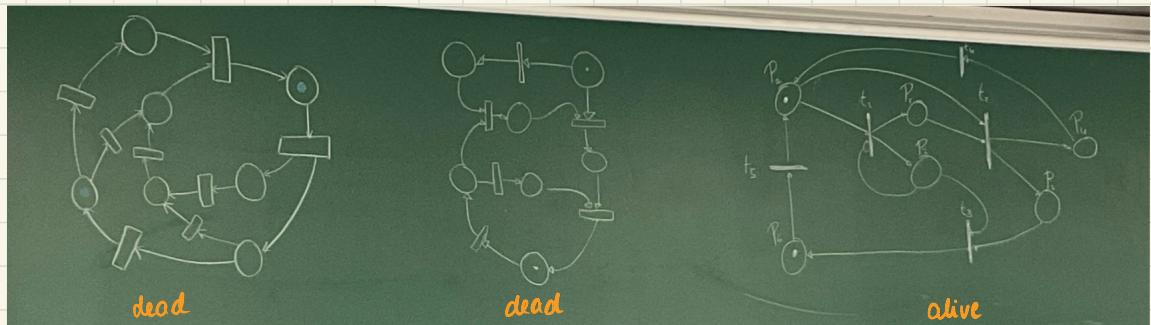
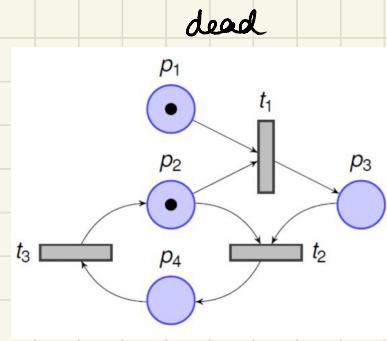
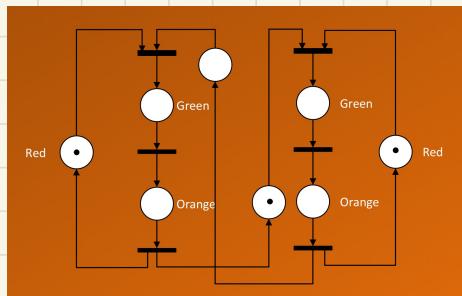
**IMP**

A petri net is **dead**, if no transition is able to fire in a given marking.

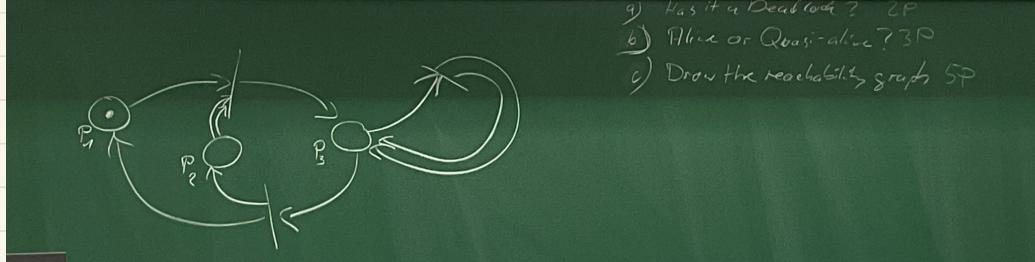
A petri net is **quasi alive**, if not dead under any future marking.

A petri net is **alive**, when all transitions are potentially fireable for all future markings.

Q) **alive / dead / quasi alive?**



Q)



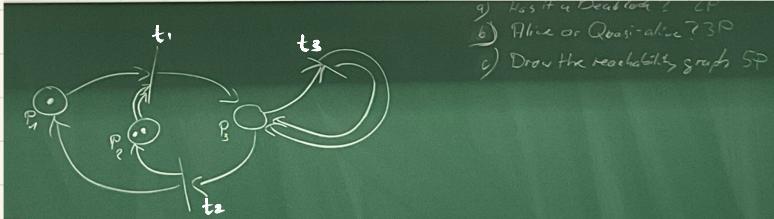
- a) Has it a Deadlock? 2P  
 b) Alive or Quasi-alive? 3P  
 c) Draw the reachability graphs 5P

a) fully dead - it has a deadlock

b) dead

c) 100

Q)



- a) Has it a Deadlock? 2P  
 b) Alive or Quasi-alive? 3P  
 c) Draw the reachability graphs 5P

(A) Yes, after  $t_1, t_2$

(B) No, it will be dead

if there's even one possibility to reach a dead loop, its dead, not quasialive

(C)  $(1, 2, 0)$  impossible due to infinity

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

$$(0, 0, 1) \rightarrow (0, 0, 2) \rightarrow (0, 0, 3) \rightarrow (0, 0, 4) \rightarrow \dots$$

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

$$(1, 1, 0) \rightarrow (1, 1, 1) \rightarrow (1, 1, 2) \rightarrow (1, 1, 3) \rightarrow \dots$$

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

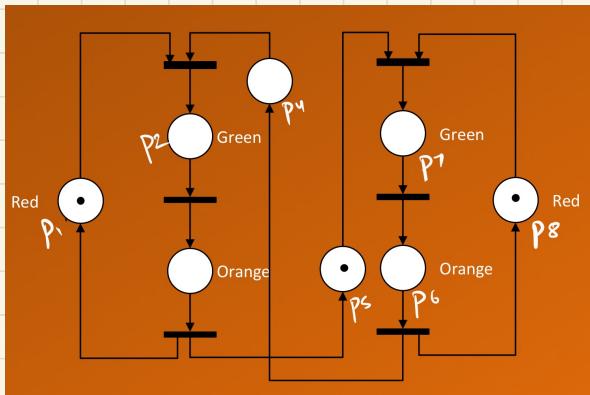
$$(2, 2, 0)$$

$$\dots \qquad \dots \qquad \dots \qquad \dots$$

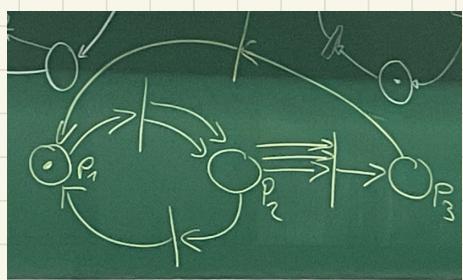
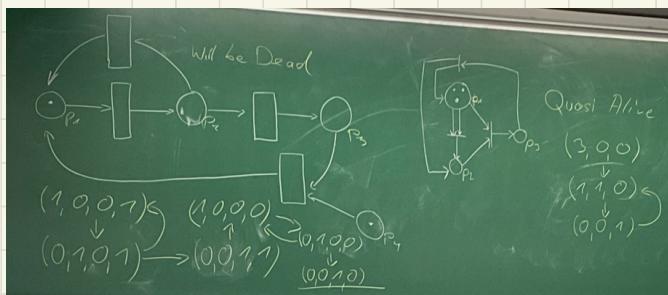
$$\downarrow \qquad \qquad \uparrow$$

$$(1, 0, 1) \rightarrow (1, 0, 2) \rightarrow (1, 0, 3) \rightarrow \dots$$

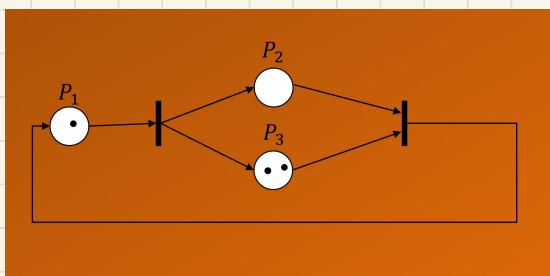
## ⇒ REACHABILITY GRAPH



$$\begin{array}{l}
 (1, 0, 0, 0, 1, 0, 0, 1) \\
 \downarrow \\
 (1, 0, 0, 0, 0, 1, 0, 0) \\
 \downarrow \\
 (1, 0, 0, 0, 0, 0, 1, 0) \\
 \downarrow \\
 (1, 0, 0, 1, 0, 0, 0, 1) \\
 \downarrow \\
 (0, 1, 0, 0, 0, 0, 0, 1) \\
 \downarrow \\
 (0, 0, 1, 0, 0, 0, 1, 0)
 \end{array}$$



$$\begin{array}{l}
 M_0 = (1 \ 0 \ 0) \\
 M_1 = (0 \ 2 \ 0) \\
 M_2 = (1 \ 1 \ 0) \\
 M_3 = (0 \ 3 \ 0) \\
 \\ 
 M_4 = (1 \ 2 \ 0) \\
 M_5 = (0 \ 4 \ 0) \\
 M_6 = (1 \ 0 \ 1) \\
 M_7 = (0 \ 2 \ 1) \\
 M_8 = (1 \ 2 \ 0)
 \end{array}$$

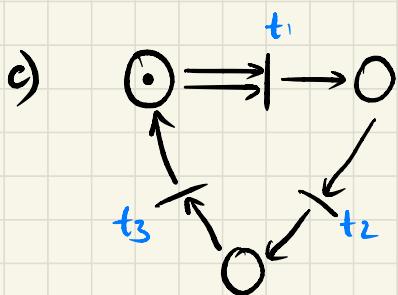
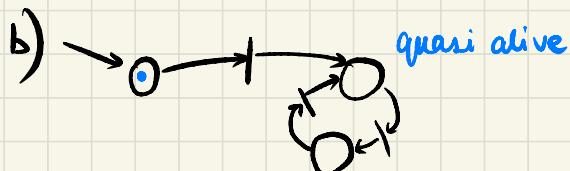
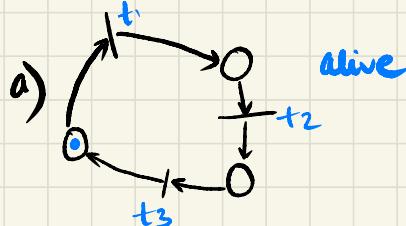


$$\begin{array}{l}
 M_0 = (1 \ 0 \ 2) \\
 M_1 = (0 \ 1 \ 3) \\
 M_2 = (1 \ 0 \ 2)
 \end{array}$$

g) Develop a petri net with

3 places & 3 transitions

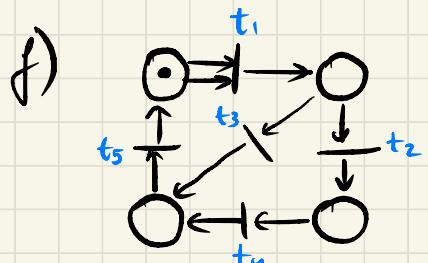
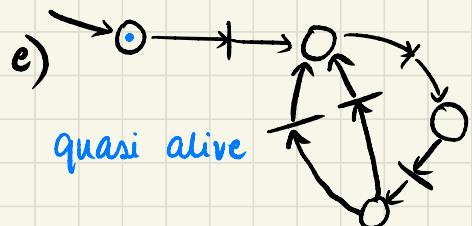
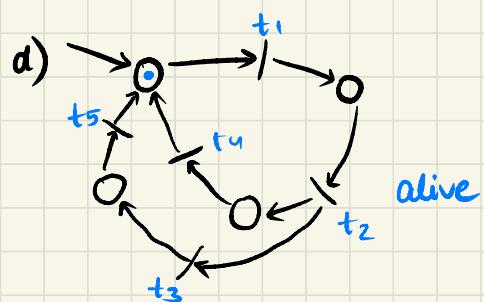
- (a) alive
- (b) quasi alive
- (c) dead



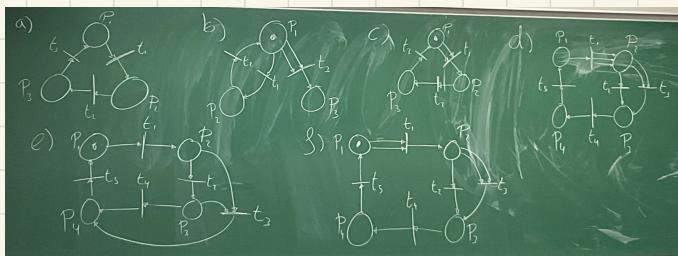
neither / dead

4 places and 5 transitions

- (d) alive
- (e) quasi alive
- (f) dead



**NOTE**  
only transition can generate tokens, not a place (circle)

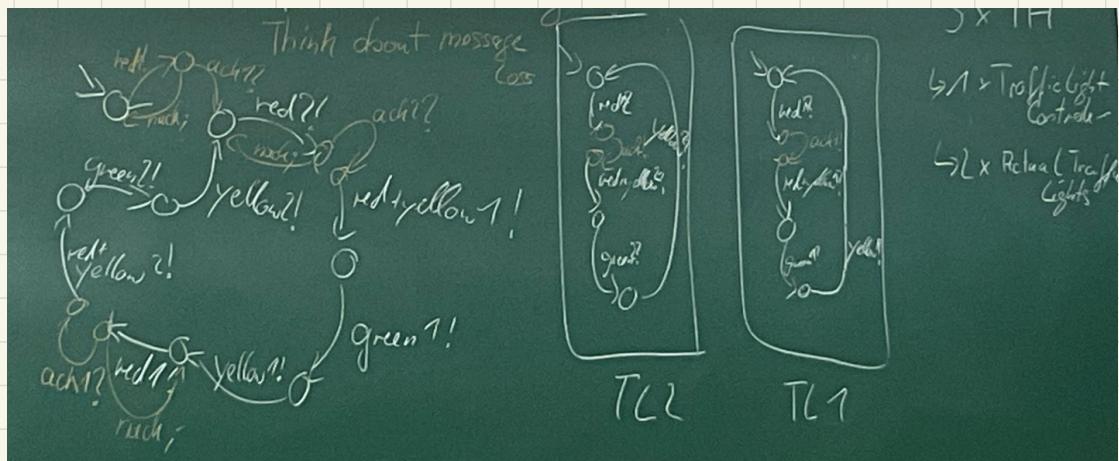


# TOPIC : INTERFACE AUTOMATA

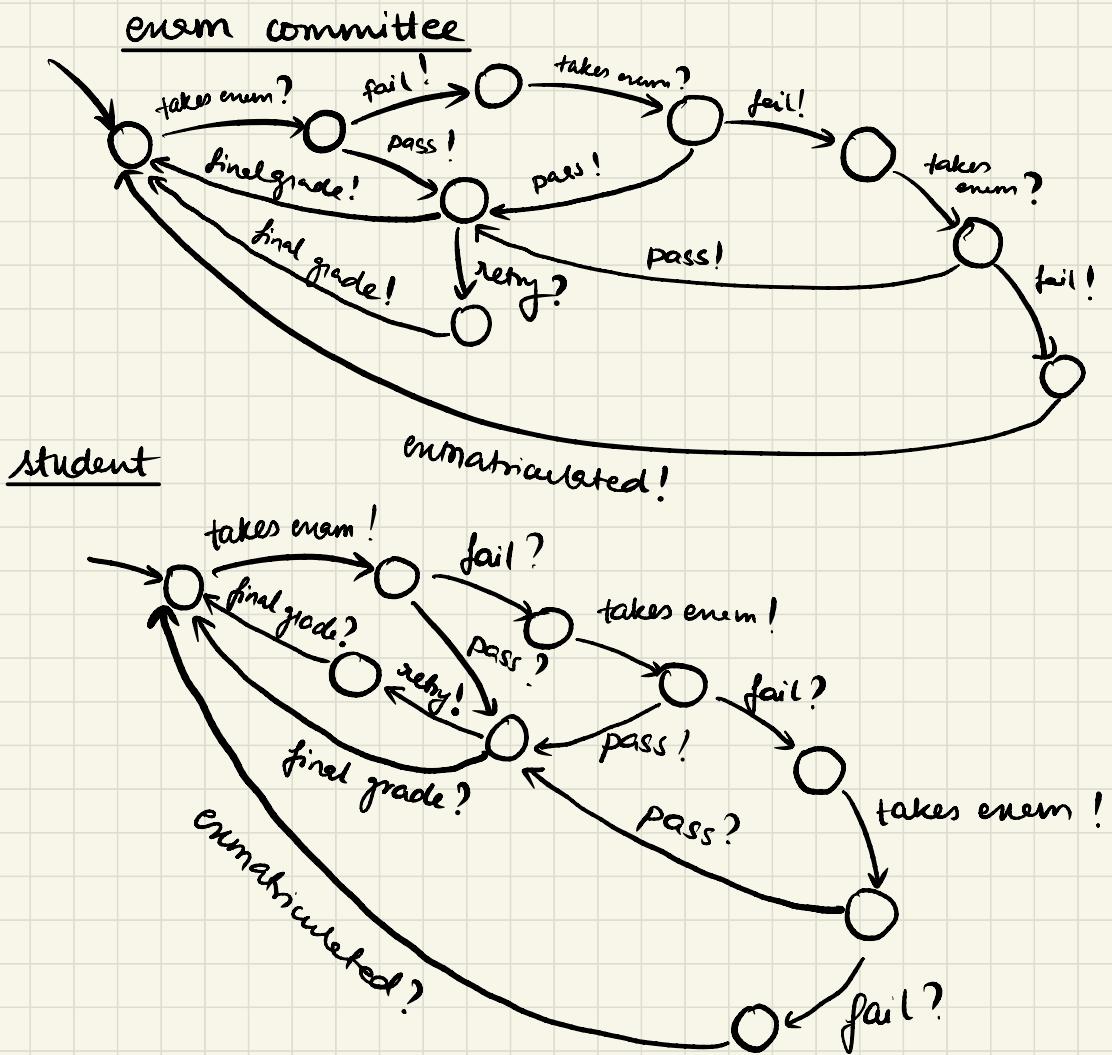
## ⇒ MODELLING

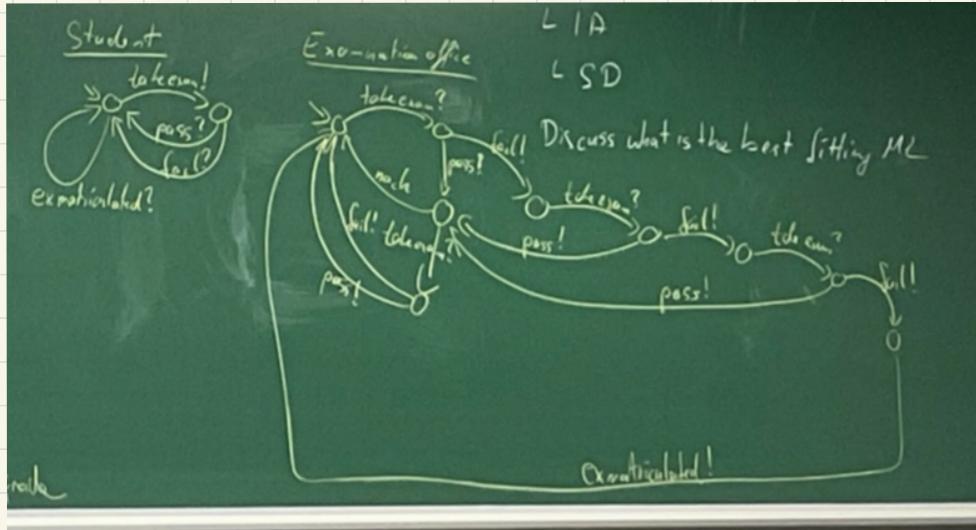
Q) Model a traffic light using interface automata

→ 1 traffic controller, 2 traffic lights



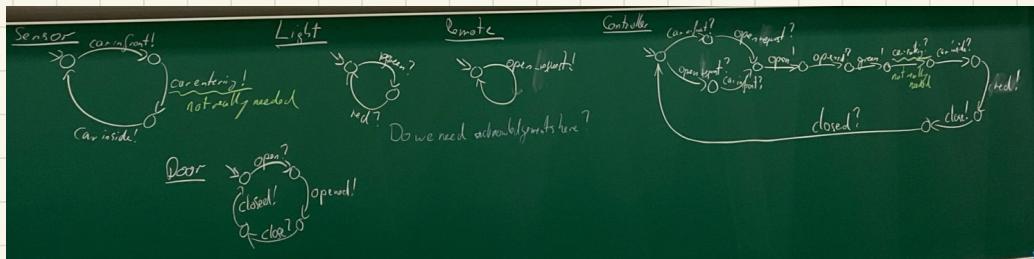
- Q) A student can take the very hard ESBFB exam up to 3 times. If the student passes one try, the course is passed and only one retry is permitted. In case of a retry, the best result is accounted for. If the student fails three times, the studies end.  
 Model with interface automata.





## Q Model the entering of a Car into a Garage with Interface Automata.

1. Car waits in front of garage door
2. Driver pushes the button of the remote control
3. Door opens
4. When door opens, signal light switches to green.
5. The car enters garage
6. The door closes and signal light switches back to red.
7. The door is closed.



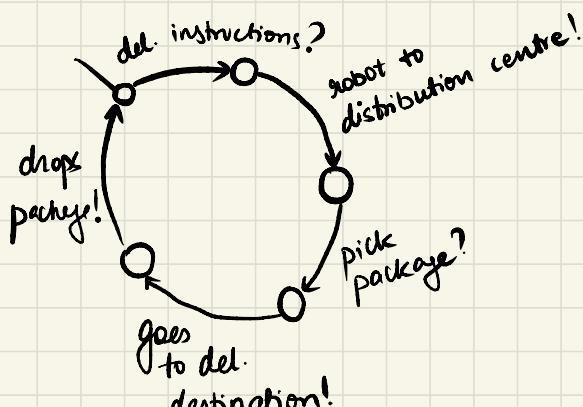
Q

Q23. Draw the Interface Automata for a Package Delivery Robot (6P) and make sure there is an event in case there is some lacking information:

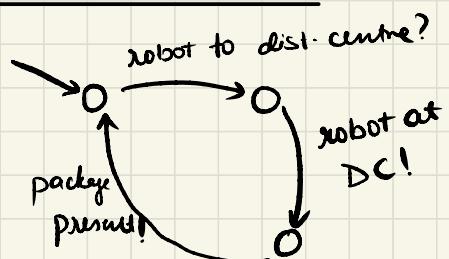
1. Robot receives delivery instructions.
2. Navigates to the distribution centre.
3. Picks up the package.
4. Navigates to the delivery destination.
5. Drops the package

Convert the interface automata to IBD (3P) and sequence diagram (3P)

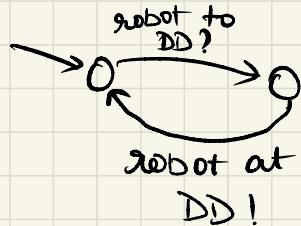
### Robot



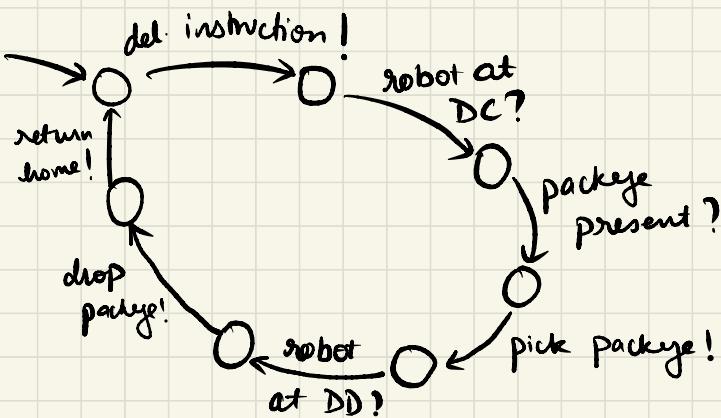
### Distribution centre

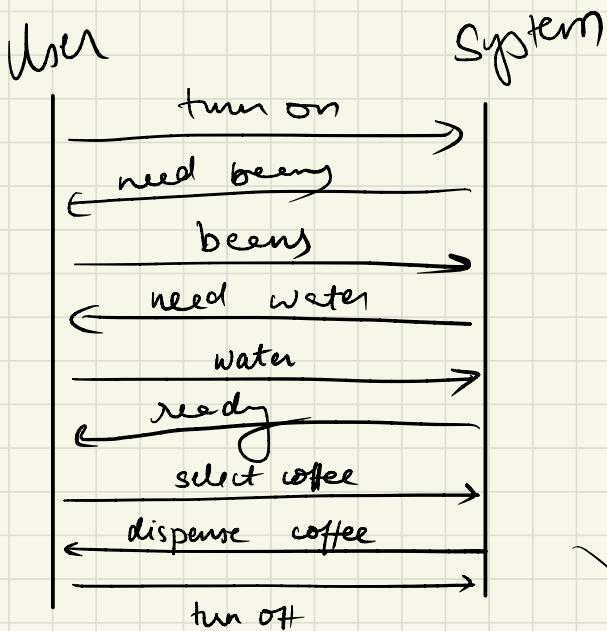
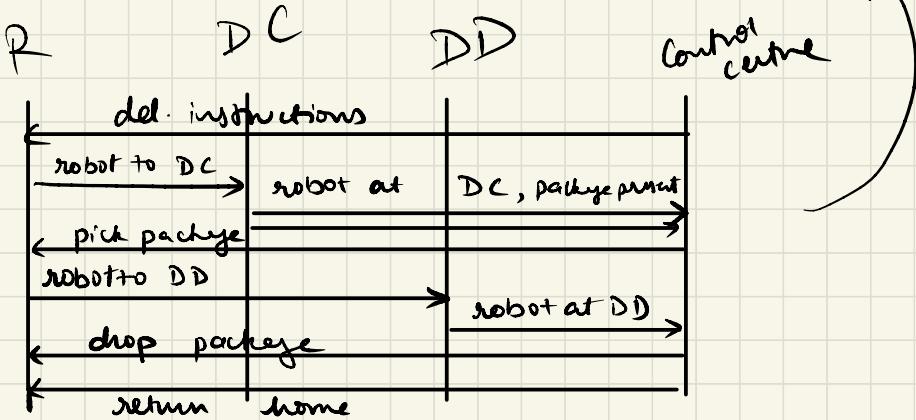


### Delivery destination

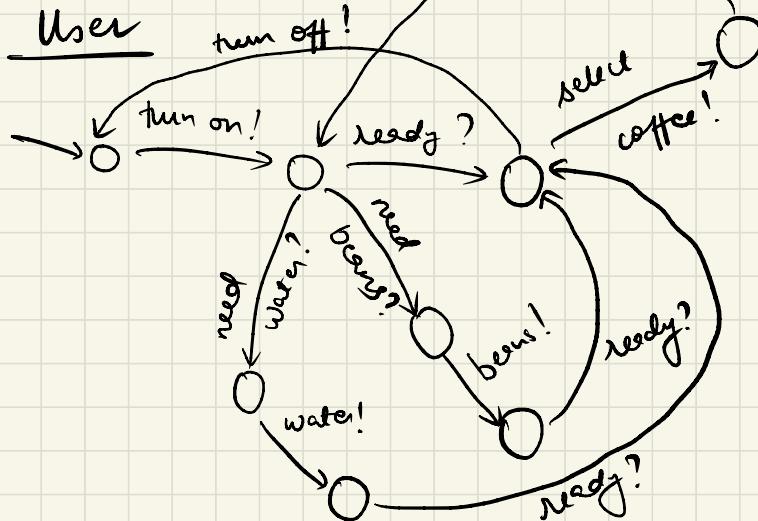


### Control System

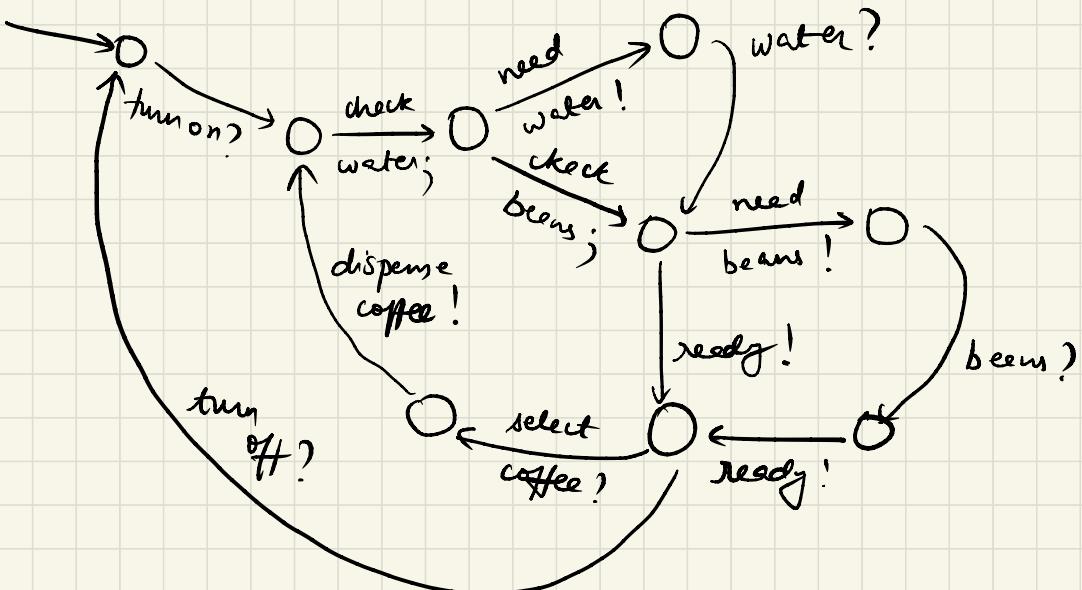




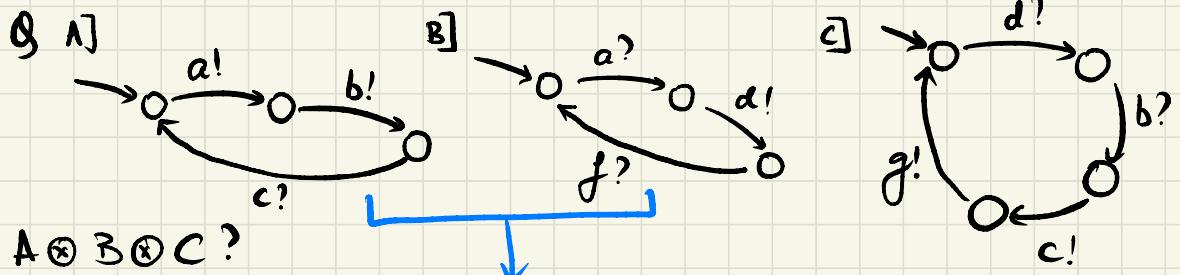
## Q Coffee machine



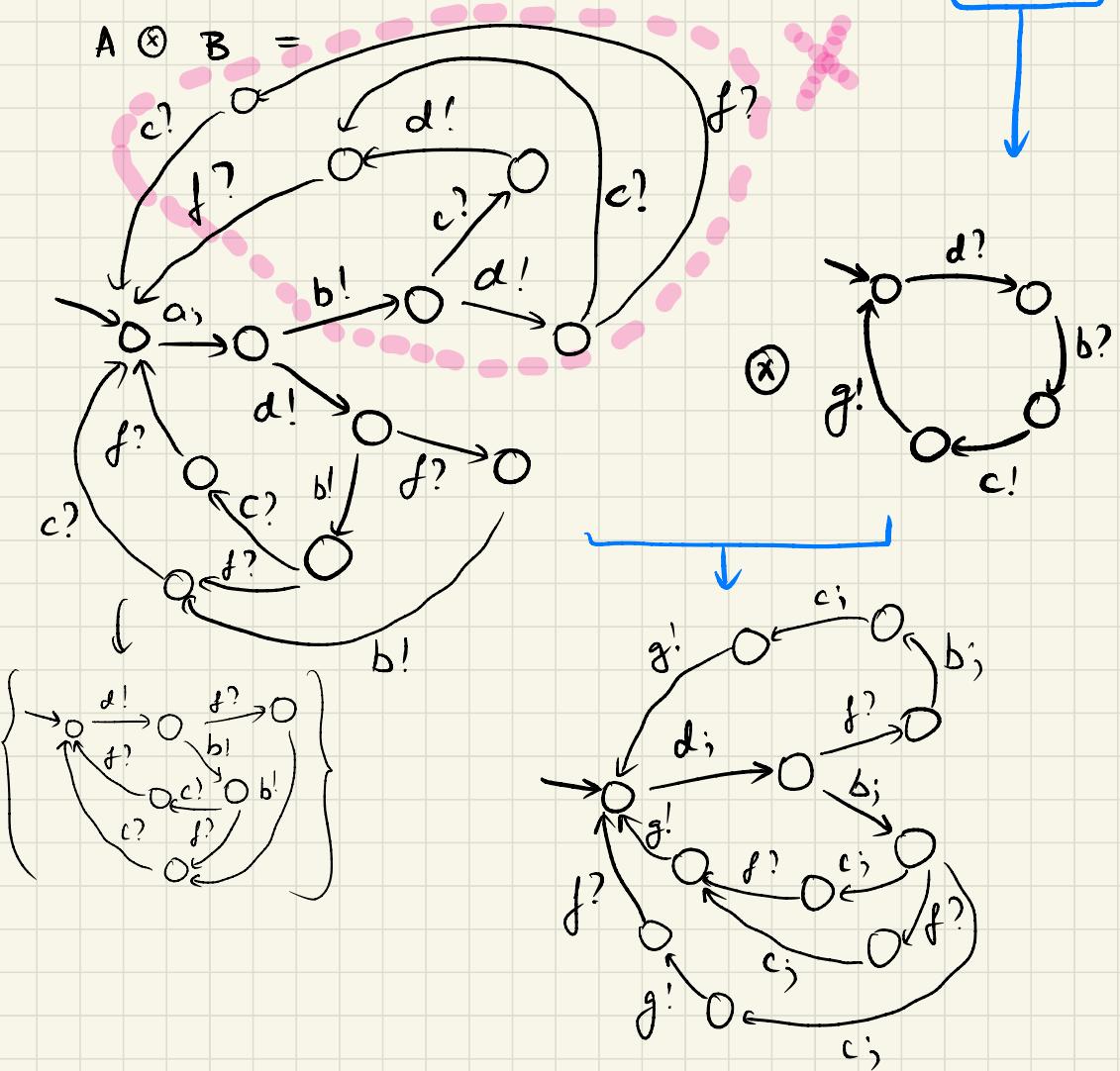
## System



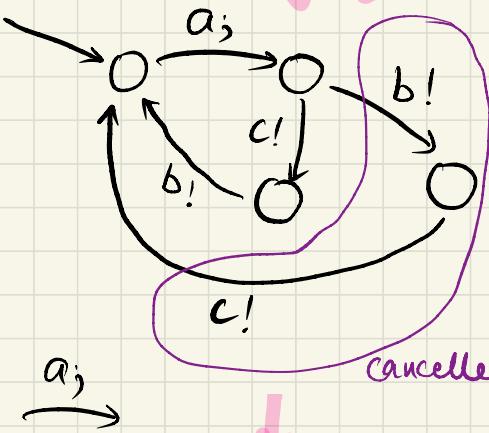
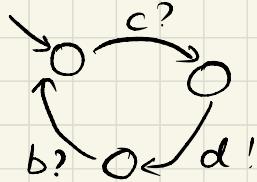
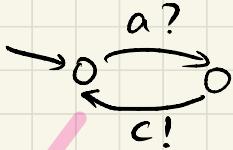
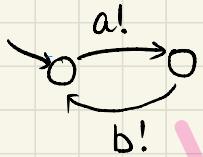
## ⇒ COMPOSING IA's



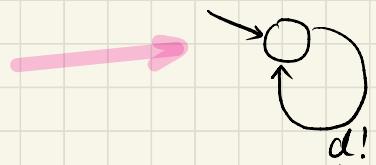
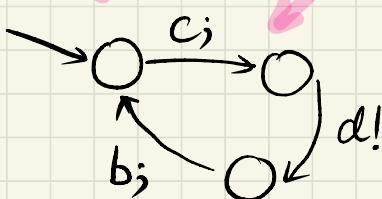
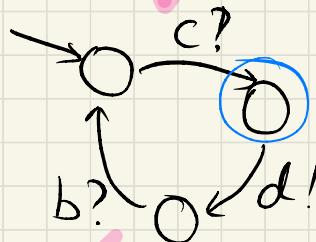
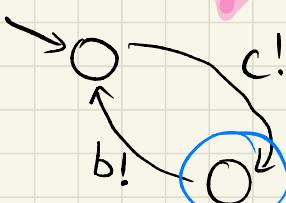
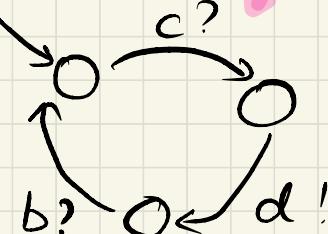
$$A \otimes B =$$

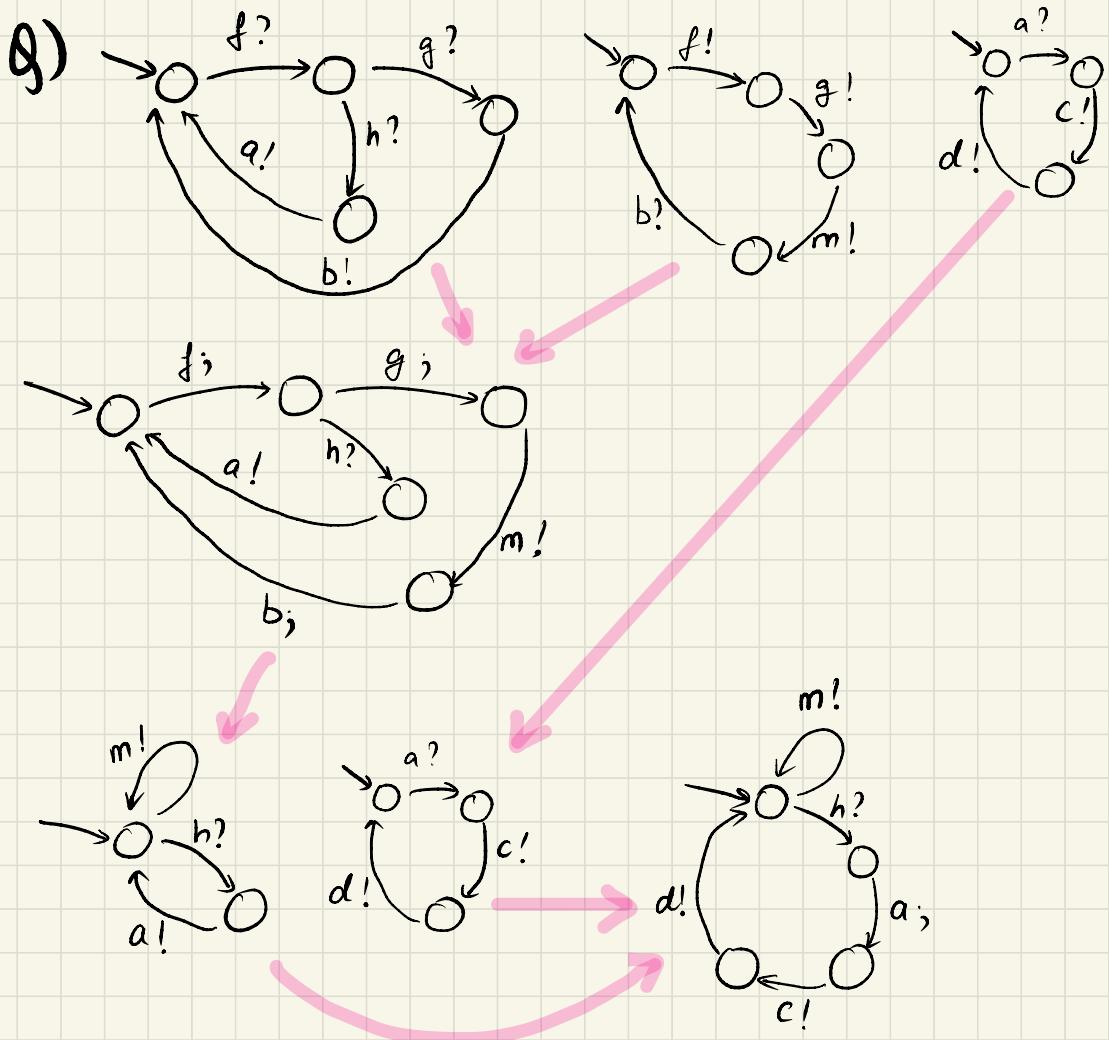
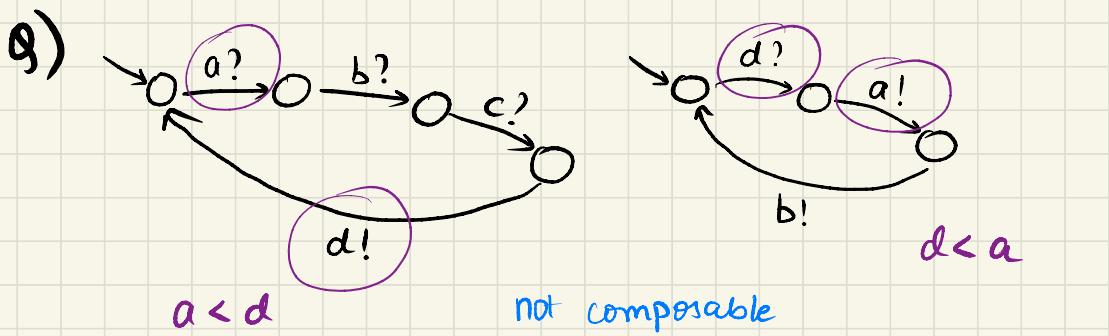


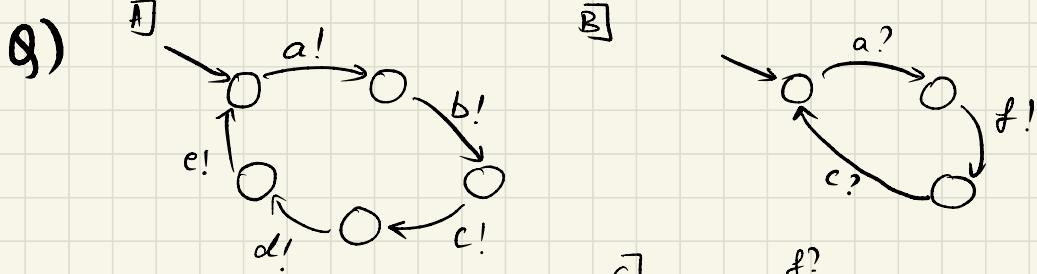
Q)



cancelled because b needs to be after c

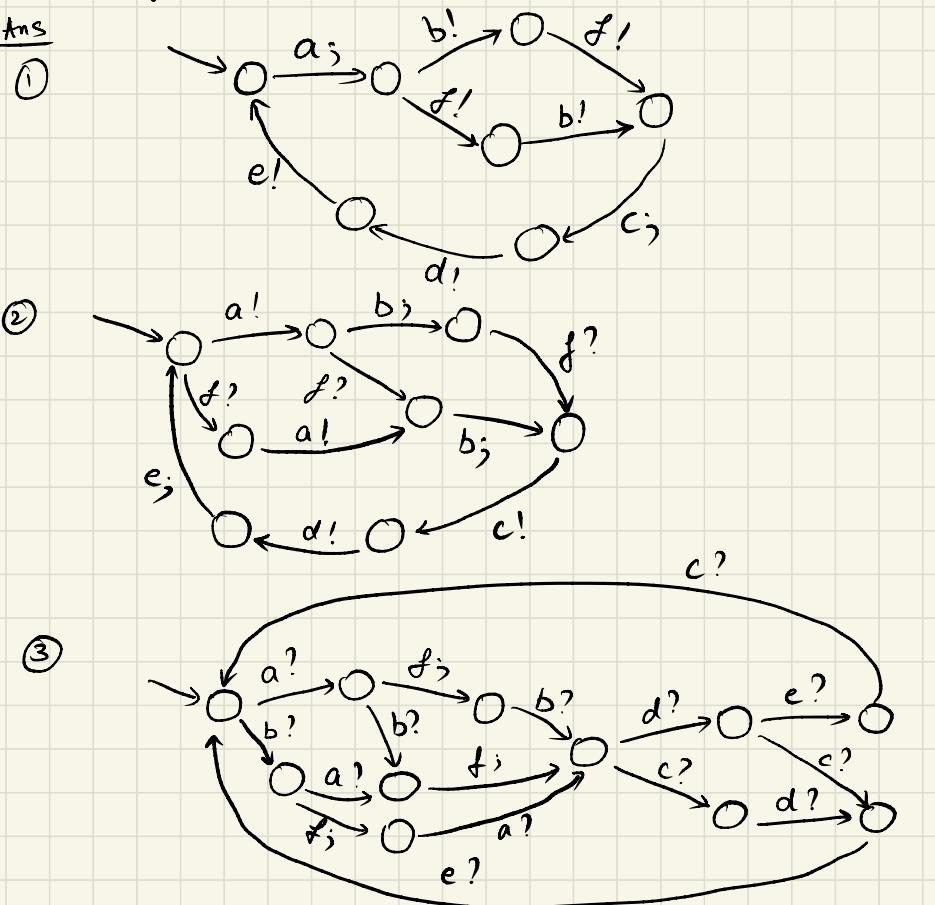




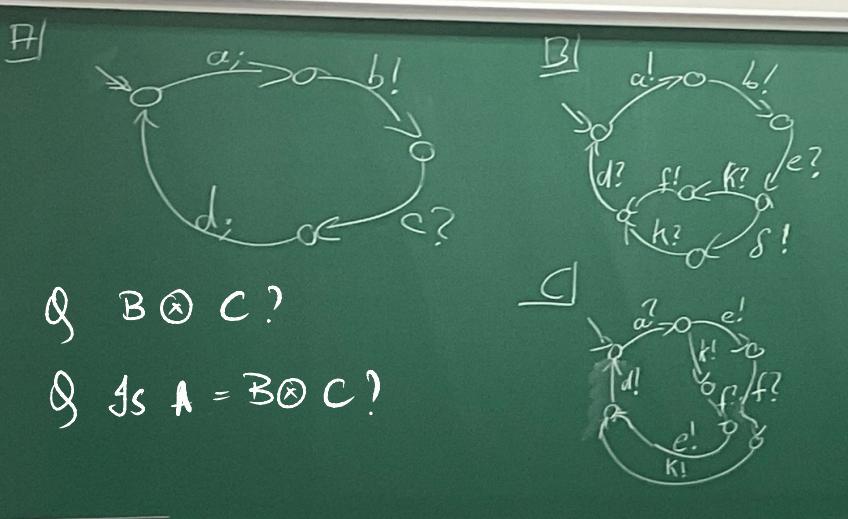


- ① Compose  $A \otimes B$
- ② Compose  $A \otimes C$
- ③ Compose  $B \otimes C$
- ④ Transform into SD
- ⑤ Transform into IBD

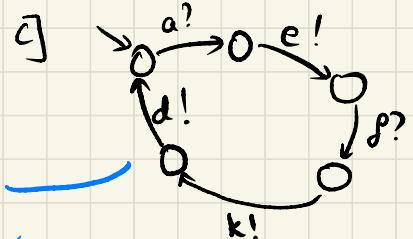
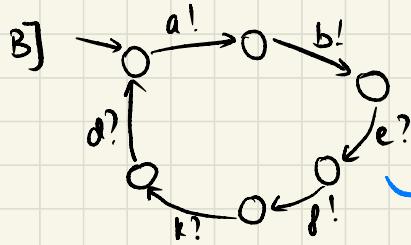
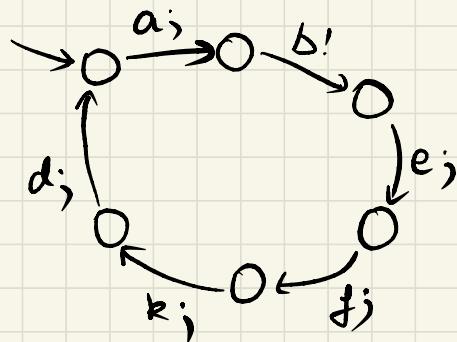
Ans



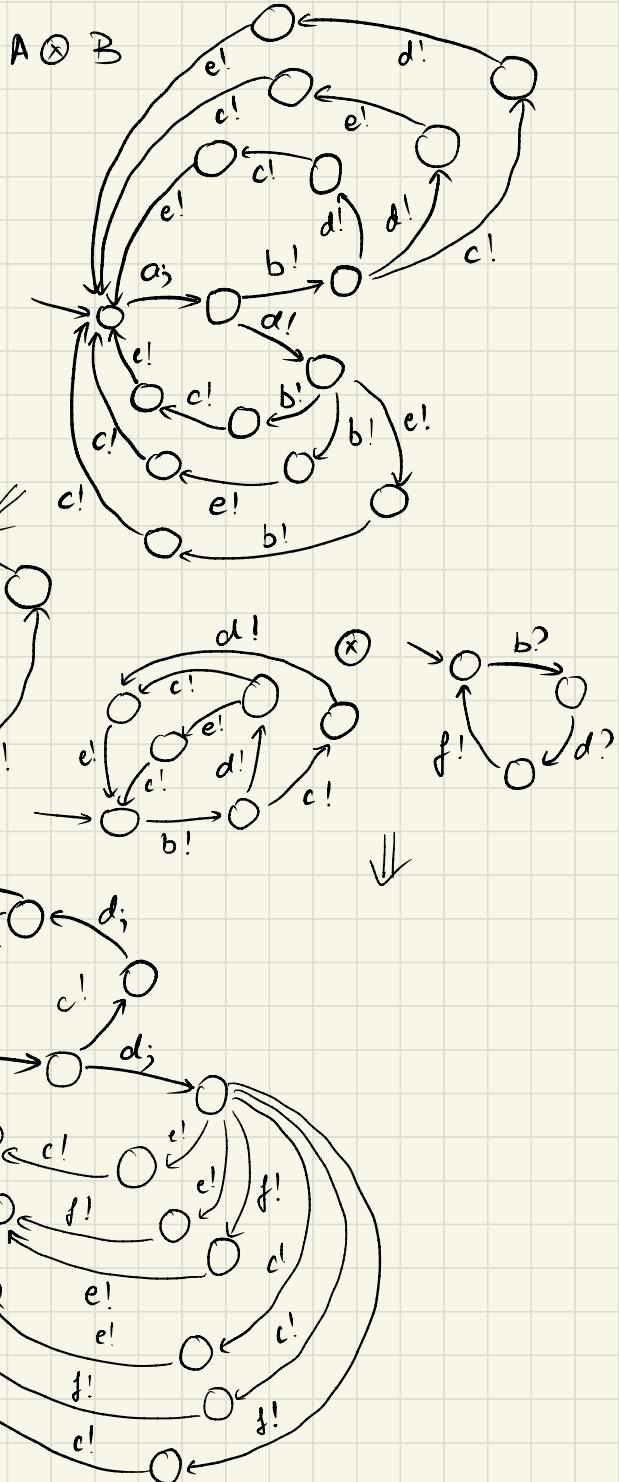
8)

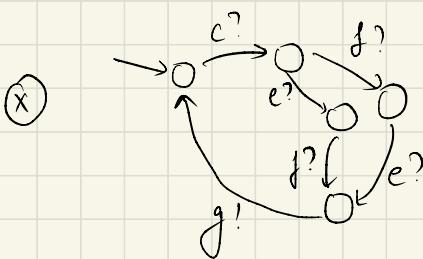
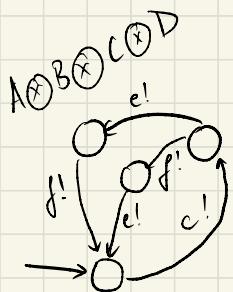


a)

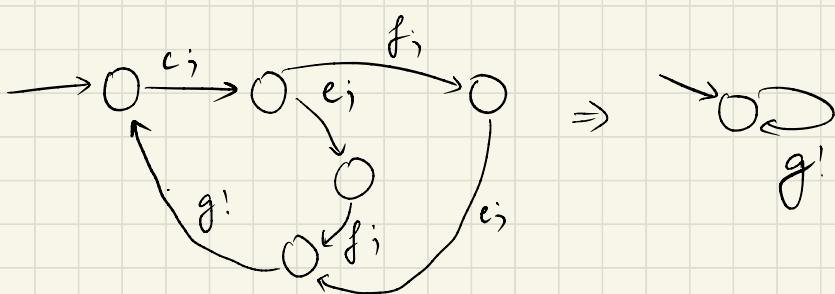
 $B \otimes C$  $\rightarrow b!$ (b) No A  $\neq$  B  $\otimes$  C

Q)



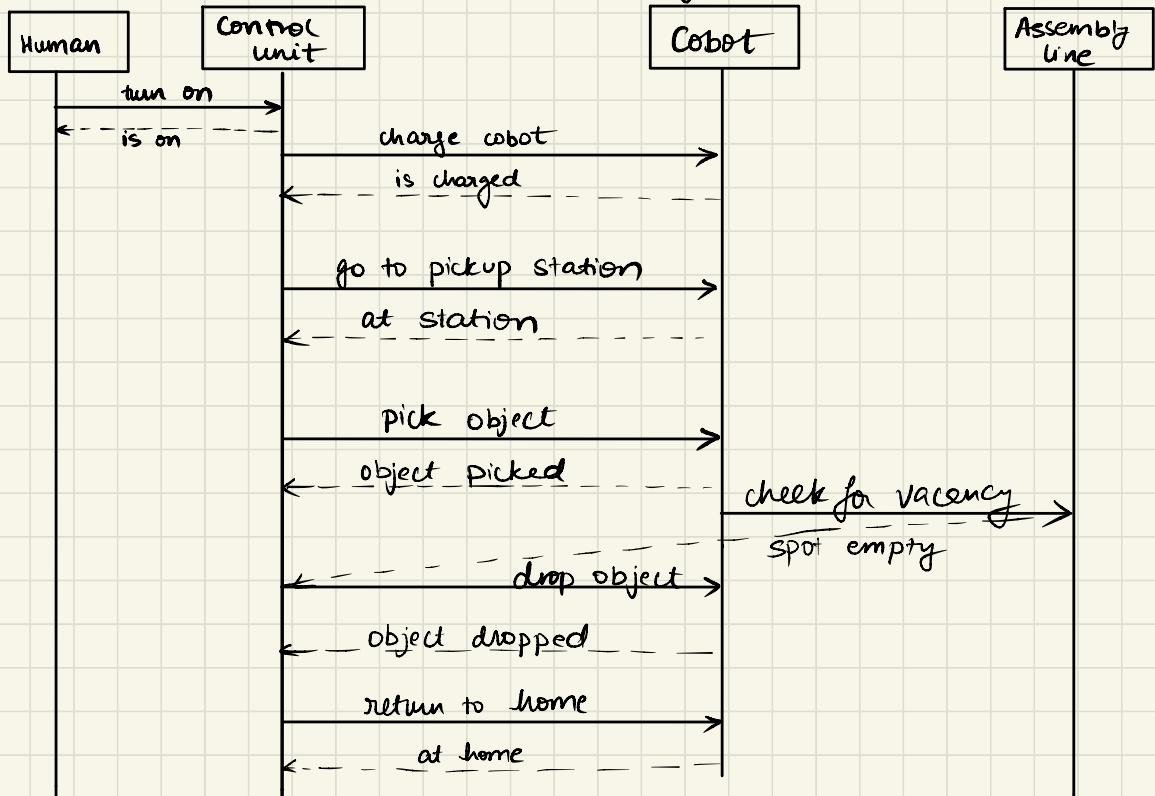


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# TOPIC: SEQUENCE DIAGRAMS

Sequence Diagram of a Cobot

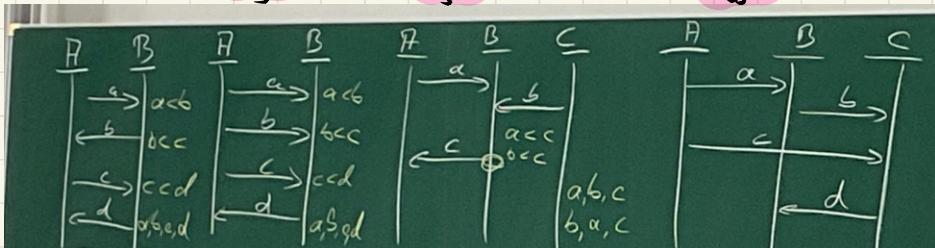


Q1

Q2

Q3

Q4



1) abcd

2) abcd

3) abc

bac

4) a &lt; b

a &lt; c

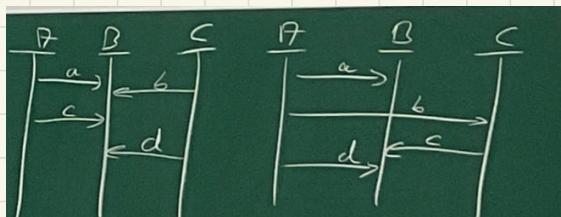
b &lt; d

c &lt; d

abcd

acbd

5) acc  
b < d  
acb d  
abc d  
abdc  
bdac



6) acb  
acd  
b < c  
b < d  
abcd  
abdc

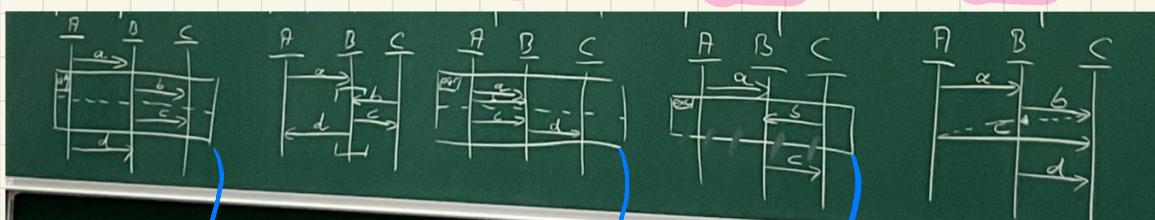
Q7

Q8

Q9

Q10

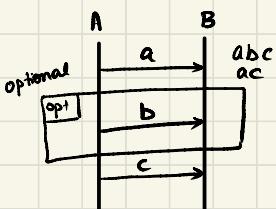
Q11



alternate

parallel

exception



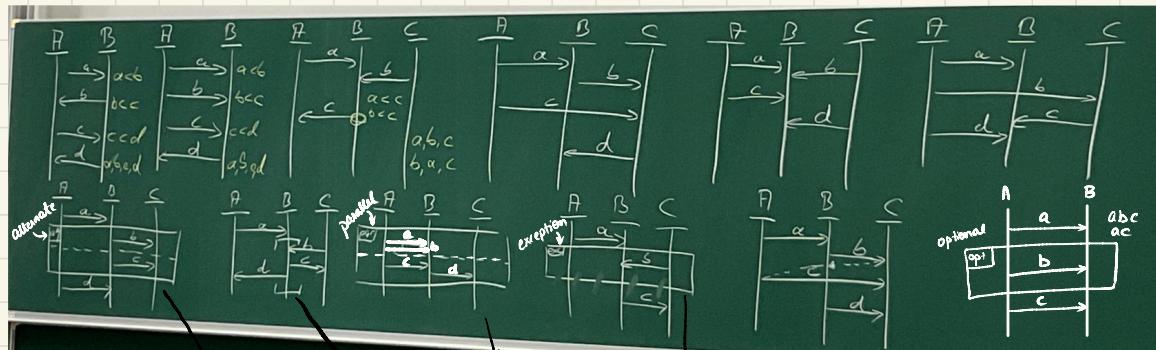
4)  $a < b$   
 $a < c$   
 $b < d$   
 $c < d$

$\begin{matrix} a \\ b \\ c \\ d \end{matrix}$   
 $\begin{matrix} a \\ c \\ b \\ d \end{matrix}$

5)  $a < c$   
 $b < d$   
 $a c b d$   
 $a b c d$   
 $a b d c$   
 $b d a c$

6)  $a < b$   
 $a < d$   
 $b < c$   
 $b < d$

$\begin{matrix} a \\ b \\ c \\ d \end{matrix}$   
 $\begin{matrix} a \\ b \\ d \\ c \end{matrix}$



7)  $a < b$   
 $a < d$   
 $a < c$

$\begin{matrix} a \\ b \\ c \\ d \end{matrix}$   
 $\begin{matrix} a \\ c \\ b \\ d \end{matrix}$   
 $\begin{matrix} a \\ d \\ b \\ c \end{matrix}$

8)  $a < d$   
 $a < c$

$\begin{matrix} a \\ b \\ c \\ d \end{matrix}$   
 $\begin{matrix} a \\ b \\ d \\ c \end{matrix}$   
 $\begin{matrix} a \\ c \\ b \\ d \end{matrix}$   
 $\begin{matrix} a \\ c \\ d \\ b \end{matrix}$   
 $\begin{matrix} a \\ d \\ b \\ c \end{matrix}$   
 $\begin{matrix} a \\ d \\ c \\ b \end{matrix}$

9)  $a < b$   
 $c < d$

$\begin{matrix} a \\ b \\ c \\ d \end{matrix}$   
 $\begin{matrix} a \\ c \\ b \\ d \end{matrix}$   
 $\begin{matrix} a \\ c \\ d \\ b \end{matrix}$   
 $\begin{matrix} c \\ d \\ a \\ b \end{matrix}$   
 $\begin{matrix} c \\ d \\ b \\ a \end{matrix}$   
 $\begin{matrix} a \\ b \\ d \\ c \end{matrix}$

10)  $a < c$   
 $a b$   
 $b$   
 $a c$

11)  $a < b$   
 $a < c$   
 $b < d$   
 $b < c$

$\begin{matrix} a \\ b \\ c \\ d \end{matrix}$   
 $\begin{matrix} a \\ b \\ d \\ c \end{matrix}$

