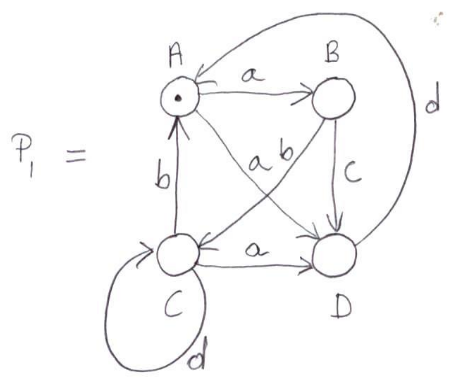
CS 3SD3. Sample solutions to the assignment 1.

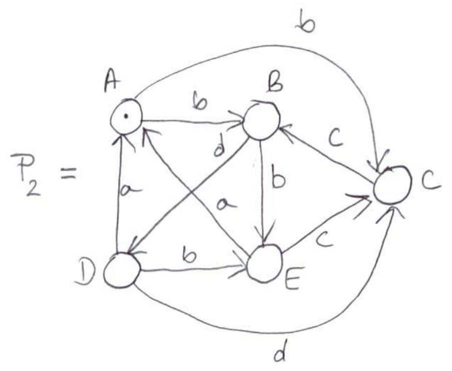
Total of this assignment is 166 pts. Each assignment is worth 11% of total. Most of solutions are not unique.

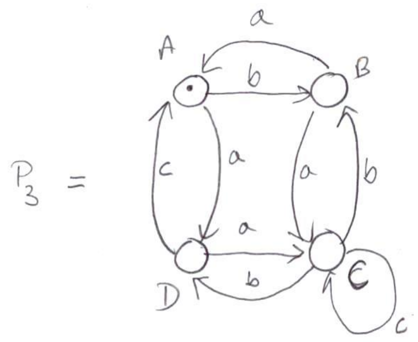
If you think your solution has been marked wrongly, write a short memo stating where marking in wrong and what you think is right, and resubmit to me during class, office hours, or just slip under the door to my office. The deadline for a complaint is 2 weeks after the assignment is marked and returned.

1.[15] a.[9] For each one of the following three processes, give the Finite State Processes (FSP) description of the labelled transition graph. Dots indicate initial states.

b.[6] Use LTSA to transform the solutions to 1.a back into labelled transition systems. Compare the results and discuss differences (if any).







Solutions (not unique!):

a.

[3] P1 = A

A = (a → B | a → D)
B = (b → C | c → D)
C = (d → C | a → D| b → A)
D = (d → A)

P1 = A
A = (a → B | a → (d → A))
B = (b → C | c → (d → A))
C = (d → C | a → (d → A) | b → A)

[3] P2 = A
A = (b → B | b → C)
B = (b → E | d → D)
C = (c → B)
D = (a → A | b → E | d → C)
E = (a → A | c → C)

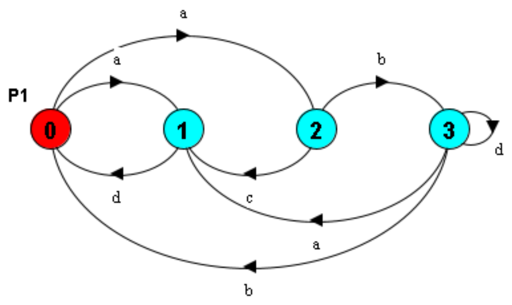
P2 = A
A = (b → B | b → (c → B))
B = (b → E | d → D)
D = (a → A | b → E | d → (c → B))
E = (a → A | c → (c → B))

[3] P3 = A
A = (a → D | b → B)
B = (a → A | a → C)
C = (b → B | b → D| c → C)
D = (a → C | c → A)

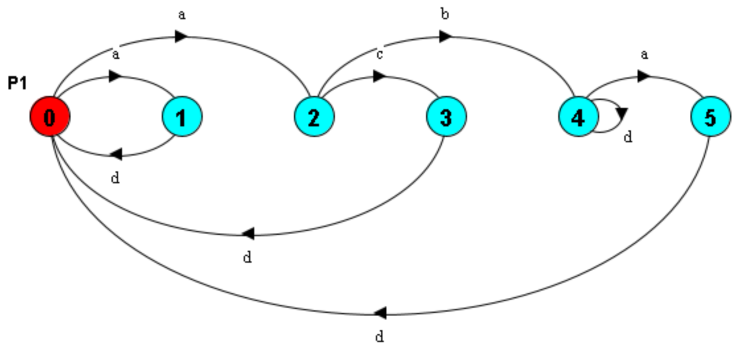
P3 = A
A = (a → (a → C | c → A) | b → B)
B = (a → A | a → C)
C = (b → B | b → (a → C | c → A)| c → C)

b.
[2]

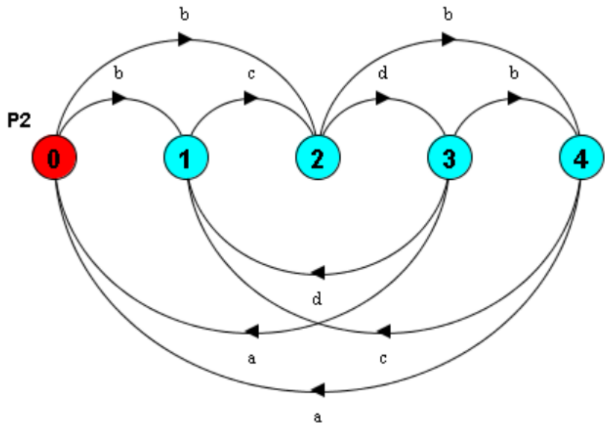
```
P1 = A,
A = (a -> B | a -> D),
B = (b -> C | c -> D),
C = (d -> C | a -> D| b -> A),
D = (d -> A).
```



```
P1 = A,
A = (a -> B | a -> (d -> A)),
B = (b -> C | c -> (d -> A)),
C = (d -> C | a -> (d -> A)).
```

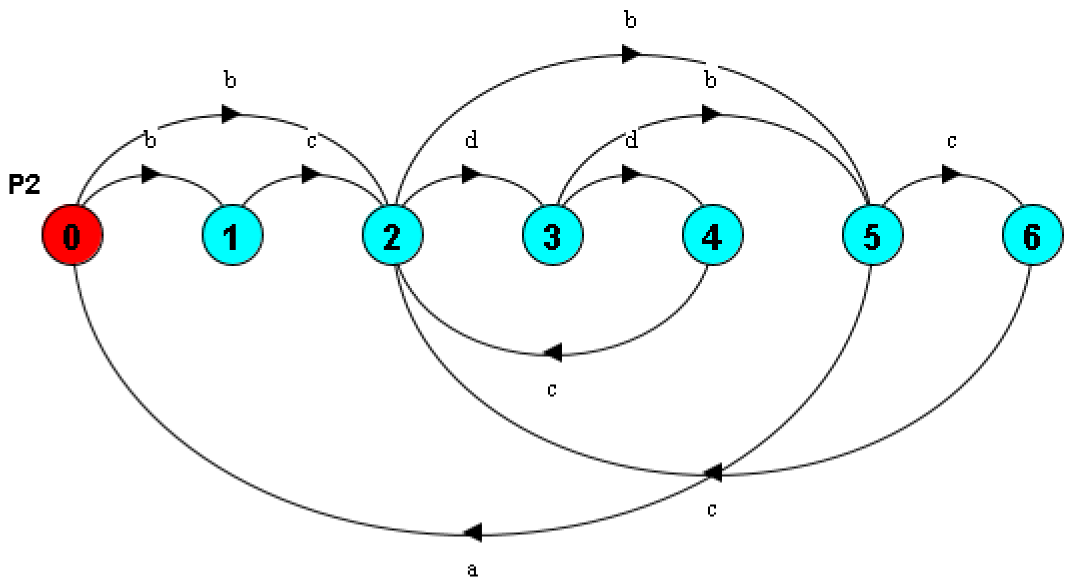


[2]



```
P2 = A,
A = (b -> B | b -> C),
B = (b -> E | d -> D),
C = (c -> B),
D = (a-> A |b -> E | d -> C),
E = (a -> A | c -> C).
```

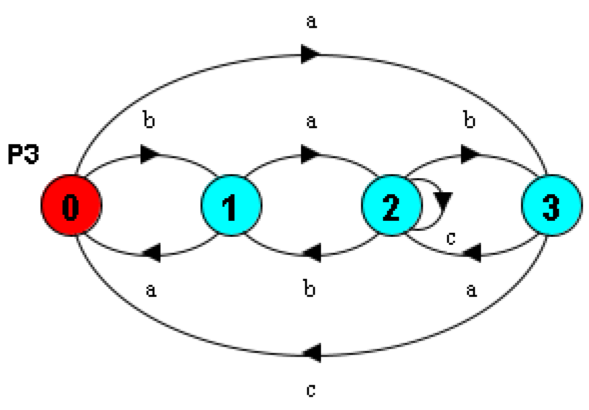
```
P2=A,
A = (b-> B |b->(c-> B)),
B = (b-> E |d-> D),
D = (b-> E |d->(c-> B)),
E = (a-> A | c->(c-> B)).
```



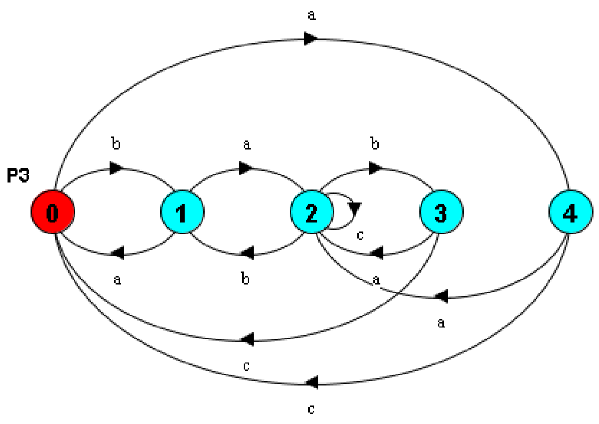
----

[2]

```
P3 = A,
A = (a -> D | b -> B),
B = (a -> A | a -> C),
C = (b -> B | b -> D| c -> C),
D = (a -> C | c -> A).
```



```
P3 = A,
A = (a -> (a -> C | c -> A) | b -> B),
B = (a -> A | a -> C),
C = (b -> B | b -> (a -> C | c -> A)| c -> C).
```



2.[10] Consider the following simple hotel reservation system.

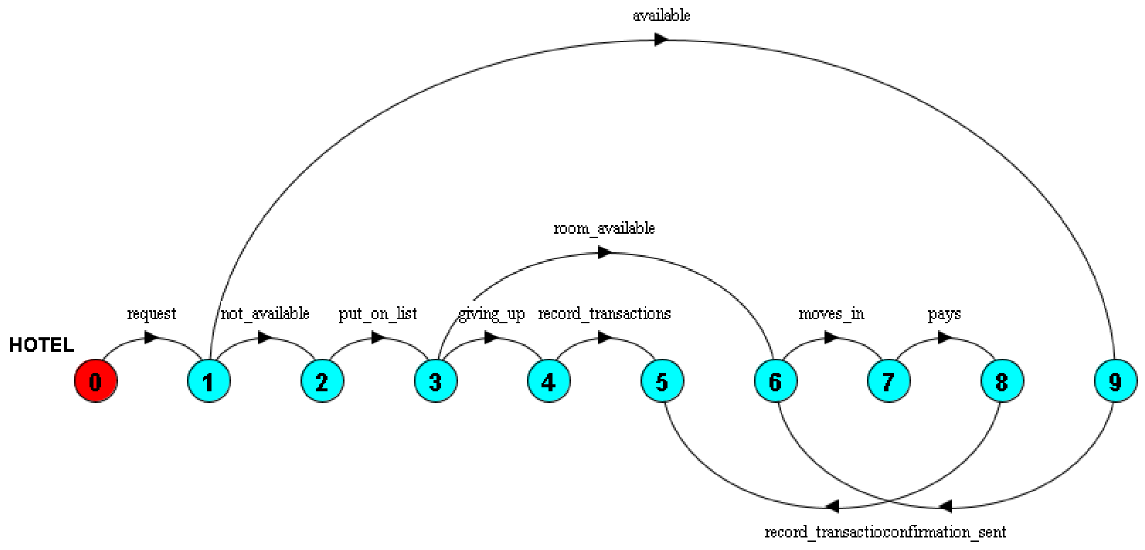
A customer makes a room request.
If room is available, a confirmation is sent to the customer,
otherwise the customer is put on a reservation list. If a room is confirmed, the customer may either use it, pay for the room, leave and the whole transaction is archived. However the customer may also cancel his/her reservation. When the customer is on waiting list, a room may become available, and then a confirmation is sent to a customer. The customer may also give up waiting and cancel his/her request.

Model this reservation system as a FSP process reservation. Note that this process always stops, so you have to use the process STOP. Also provide appropriate labelled transition system (use LTSA)

Solution:
[8]

```
HOTEL = (request -> REQUESTED),
REQUESTED = (available -> confirmation_sent -> CONFIRMED
        | not_available -> put_on_list -> ON_WAITING_LIST),
CONFIRMED = (moves_in -> pays -> ARCHIVED),
ON_WAITING_LIST = (room_available -> CONFIRMED | giving_up -> CANCELED),
ARCHIVED = (record_transactions -> STOP),
CANCELED = (record_transactions -> STOP).
```

[2]



3.[10] A miniature portable FM radio has three controls. An on/off switch turns the device on

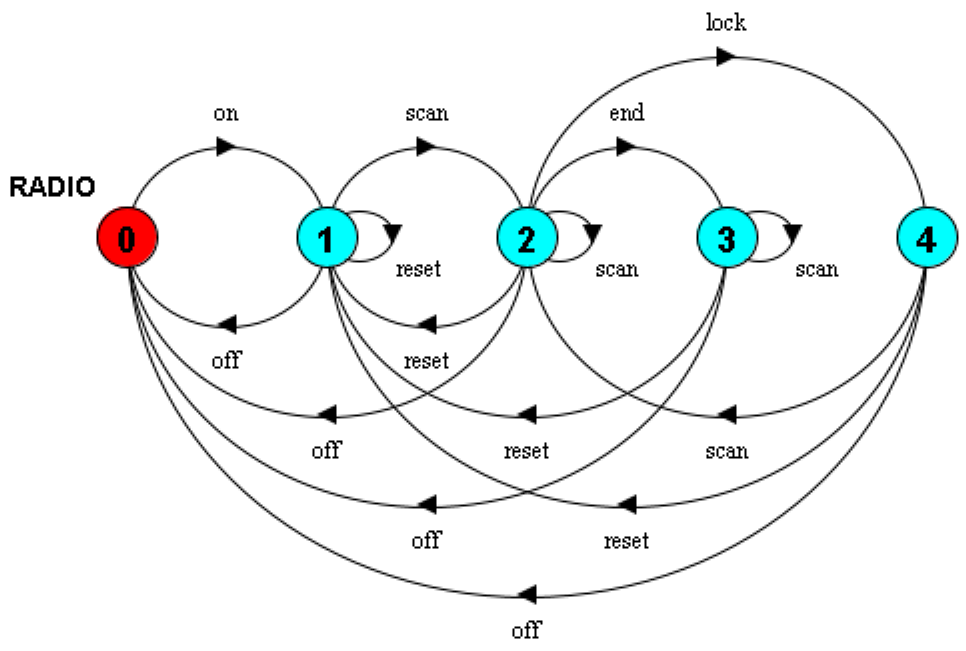
and off. Tuning is controlled by two buttons scan and reset which operate as follows. When the radio is turned on or reset is pressed, the radio is tuned to the top frequency of the FM band (108 MHz). When scan is pressed, the radio scans towards the bottom of the band (88 MHz). It stop scanning when it locks onto a station or it reaches the bottom (end). If the radio is currently tuned to a station and scan is pressed then it start to scan from the frequency of that station towards the bottom. Similarly, when reset is pressed the receiver tunes to the top. Model the radio as a *FSP* process RADIO. Also provide an appropriate labelled transition system.
Hint: The alphabet of RADIO is {on, off, scan, reset, lock, end}.

Solution:
[8]
FSP:

```
/* FM radio */

RADIO     = OFF,
OFF       = (on -> TOP),
TOP       = (scan -> SCANNING | reset -> TOP | off -> OFF),
SCANNING = (scan -> SCANNING | reset -> TOP | off -> OFF | lock -> TUNED | end ->
BOTTOM),
TUNED      = (scan -> SCANNING | reset -> TOP | off -> OFF),
BOTTOM     = (scan -> BOTTOM    | reset -> TOP | off -> OFF).
```

[2]



4.[15] Program the radio of Question 3 in Java, complete with graphic display (if you can).

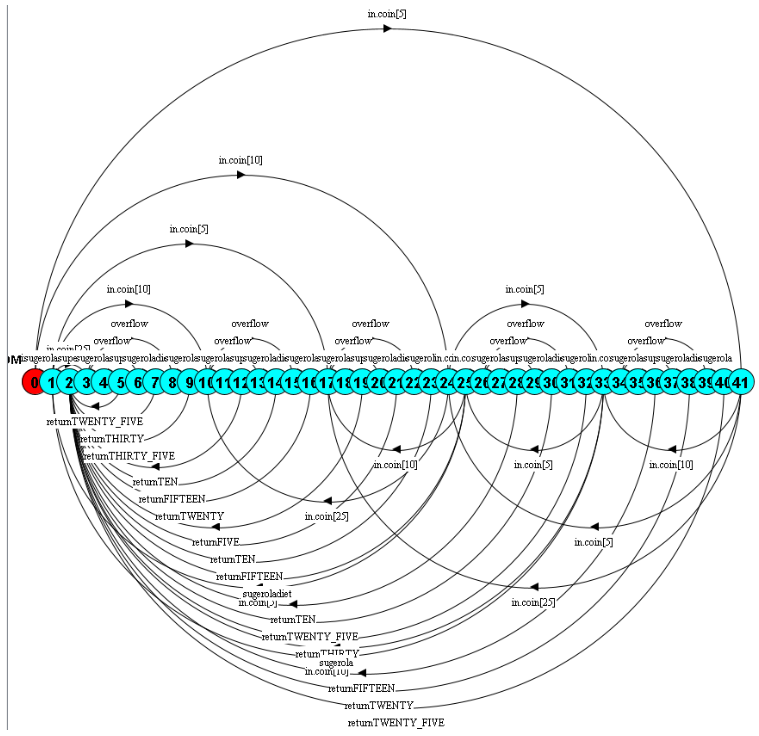
Java solutions will not be posted.

5.[15] A drinks dispending machine charges 15c for can of Sugerola, 20c for a can of SugerolaDiet and 25c for a can of SugerolaSuperDiet . The machine accepts coins with denominations 5c, 10c and 25c and gives changes. Model the machine as an *FSP* process, DRINKS.

Solution (not unique):
[12]

```
DM = ZERO,
ZERO = (in.coin [5] -> FIVE | in.coin [10] -> TEN | in.coin [25] -> TWENTY_FIVE),
FIVE = (in.coin [5] -> TEN | in.coin [10] -> FIFTEEN | in.coin [25] -> THIRTY),
TEN = (in.coin [5] -> FIFTEEN | in.coin [10] -> TWENTY | in.coin [25] -> THIRTY_FIVE),
FIFTEEN = (sugerola -> STOP | in.coin [5] -> TWENTY | in.coin [10] -> TWENTY_FIVE | in.coin [25] -> FORTY),
TWENTY = (sugeroladiet -> STOP | in.coin [5] -> TWENTY_FIVE | in.coin [10] -> THIRTY| in.coin [25] -> FORTY_FIVE),
TWENTY_FIVE = (sugerolasuperdiet -> STOP | in.coin [5] -> THIRTY | in.coin [10] -> THIRTY_FIVE | in.coin [25] -> FIFTY),
THIRTY = (overflow -> sugerola -> returnFIFTEEN -> STOP
                        | overflow -> sugeroladiet -> returnTEN -> STOP
                        | overflow -> sugerolasuperdiet -> returnFIVE -> STOP),
THIRTY_FIVE = (overflow -> sugerola -> returnTWENTY -> STOP
                        | overflow -> sugeroladiet -> returnFIFTEEN -> STOP
                        | overflow -> sugerolasuperdiet -> returnTEN -> STOP),
FORTY = (overflow -> sugerola -> returnTWENTY_FIVE -> STOP
                        | overflow -> sugeroladiet -> returnTWENTY -> STOP
                        | overflow -> sugerolasuperdiet -> returnFIFTEEN -> STOP),
FORTY_FIVE = (overflow -> sugerola -> returnTHIRTY -> STOP
                        | overflow -> sugeroladiet -> returnTWENTY_FIVE -> STOP
                        | overflow -> sugerolasuperdiet -> returnTEN -> STOP),
FIFTY = (overflow -> sugerola -> returnTHIRTY_FIVE -> STOP
                        | overflow -> sugeroladiet -> returnTHIRTY -> STOP
                        | overflow -> sugerolasuperdiet -> returnTWENTY_FIVE -> STOP).
```

[3]



6.[15] Consider the following set of FSPs:

A = ((a → (b → A)) | (c → (a → C | c → B)) | c → C))
B = (b → (a → B | c → (a → A | b → B)))
C = ((a → (b → (c → B))) | (a → C))

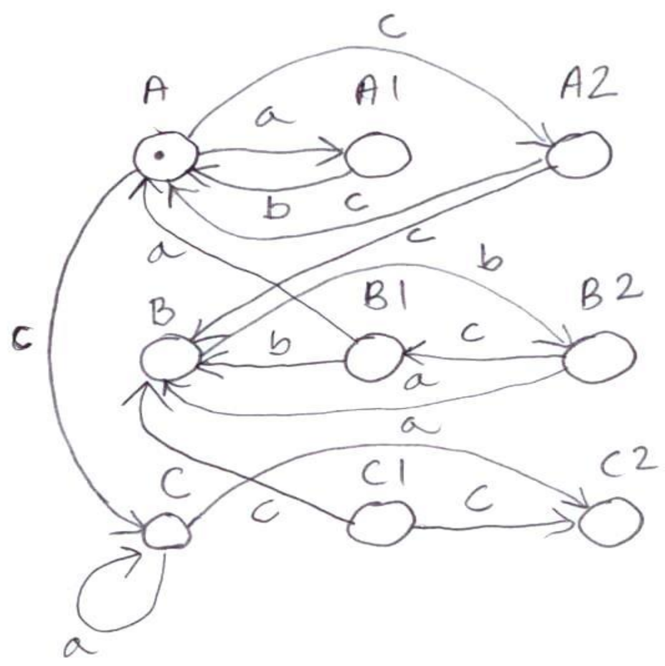
a.[12] Construct an equivalent Labelled Transition System using the rules from page 16 of Lecture Notes 2.

b.[3] Use LTSA to derive appropriate LTS, and, if different than yours, analyse and explain differences.

Solution:

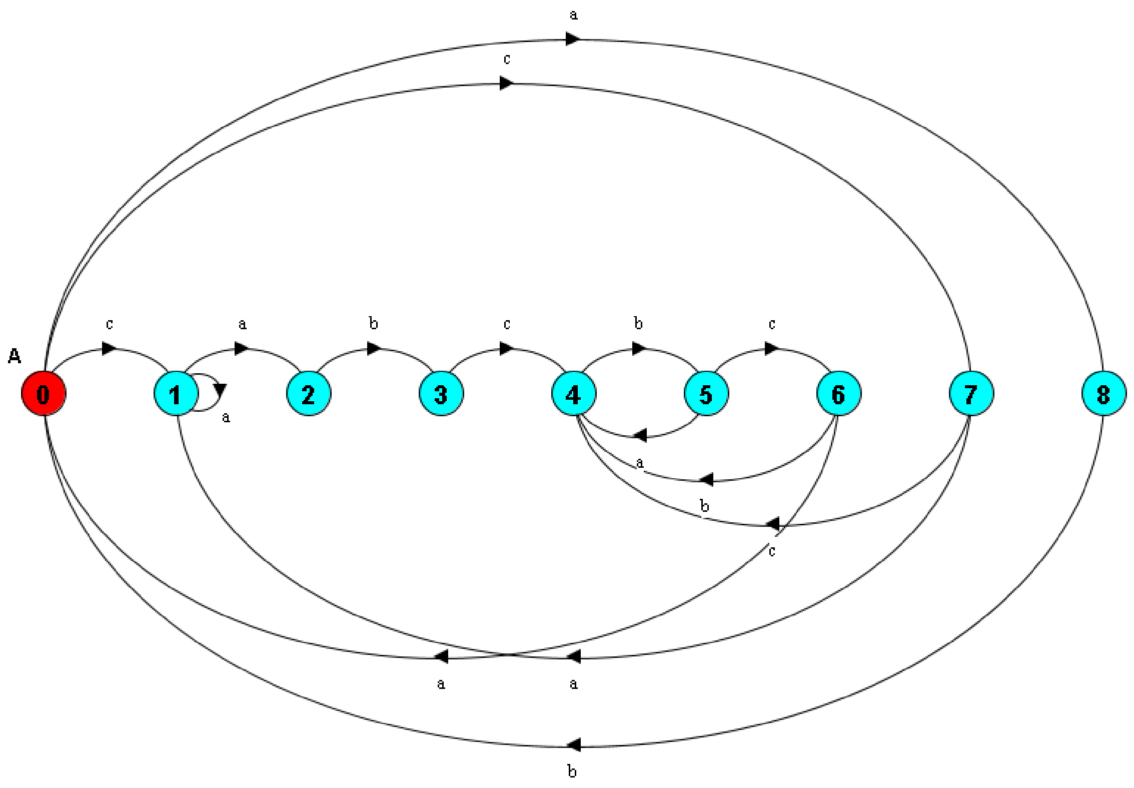
a.

A = (a → A1 | c → A2 | c → C)
A1 = (b → A)
A2 = (a → C | c → B)
B = (b → B2)
B1 = (a → A | b → B)
B2 = (a → B | c → B1)
C = (a →C2 | a → C)
C1 = (c → B)
C2 = (b → C1)



b.

```
A = (a -> A1 | c -> A2 | c -> C),
A1 = (b -> A),
A2 = (a -> C | c -> B),
B = (b -> B2),
B1 = (a -> A | b -> B),
B2 = (a -> B | c -> B1),
C = (a ->C2 | a -> C),
C1 = (c -> B),
C2 = (b -> C1).
```



7.[18] a.[8] Show that processes ||*S*1 and *S*2 generate the same Labelled Transition Systems, i.e. LTS(||*S*1) = LTS(*S*2) (or equivalently, they generate the same behaviour)

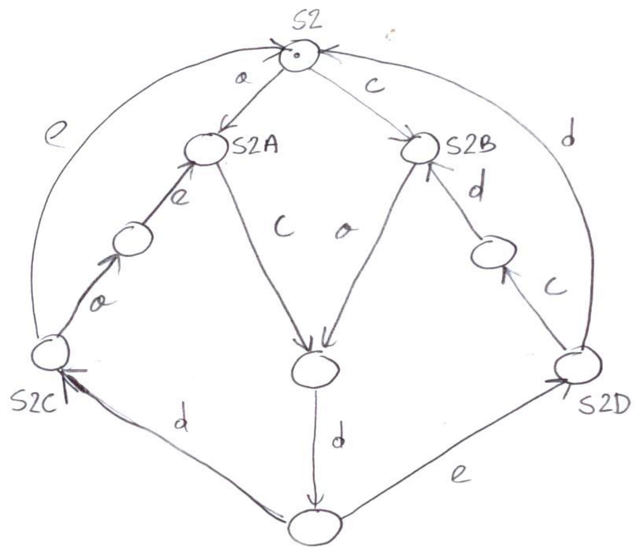
P = (*a* -> *b* -> *d* -> *P*)
Q = (c -> *b* -> *e* -> *Q*)
|| *S*1 = (*P* || *Q*)

*S*2   = (*a* -> S2A | *c* -> S2B)
S2A = (*c* -> *b* -> *d* -> S2C | *c* -> *b* -> *e* -> S2D)
S2B = (*a* -> *b* -> *d* -> S2C | *a* -> *b* -> *e* -> S2D)
S2C = (*e* -> S2 | *a* -> *e* -> S2A)
S2D = (*d* -> S2 | *c* -> *d* -> S2B)

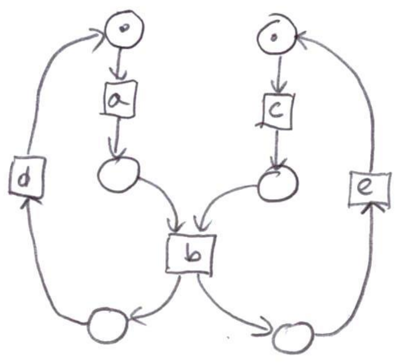
b.[10] Using a method presented on page 17 of Lecture Notes 3 and pages 10-11 of Lecture Notes 4, transform the processes ||*S*1 and *S*2 into appropriate Petri nets. Are these nets identical? Explain the difference. Which one allows *simultaneity*?

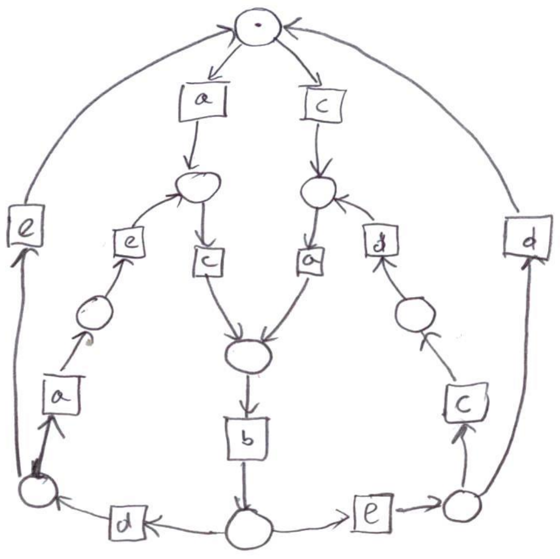
Solution:

a. LTS(||*S*1) = LTS(*S*2) and is isomorphic to the below diagram:



b. ||S1 corresponds to N1 and S2 corresponds to N2.

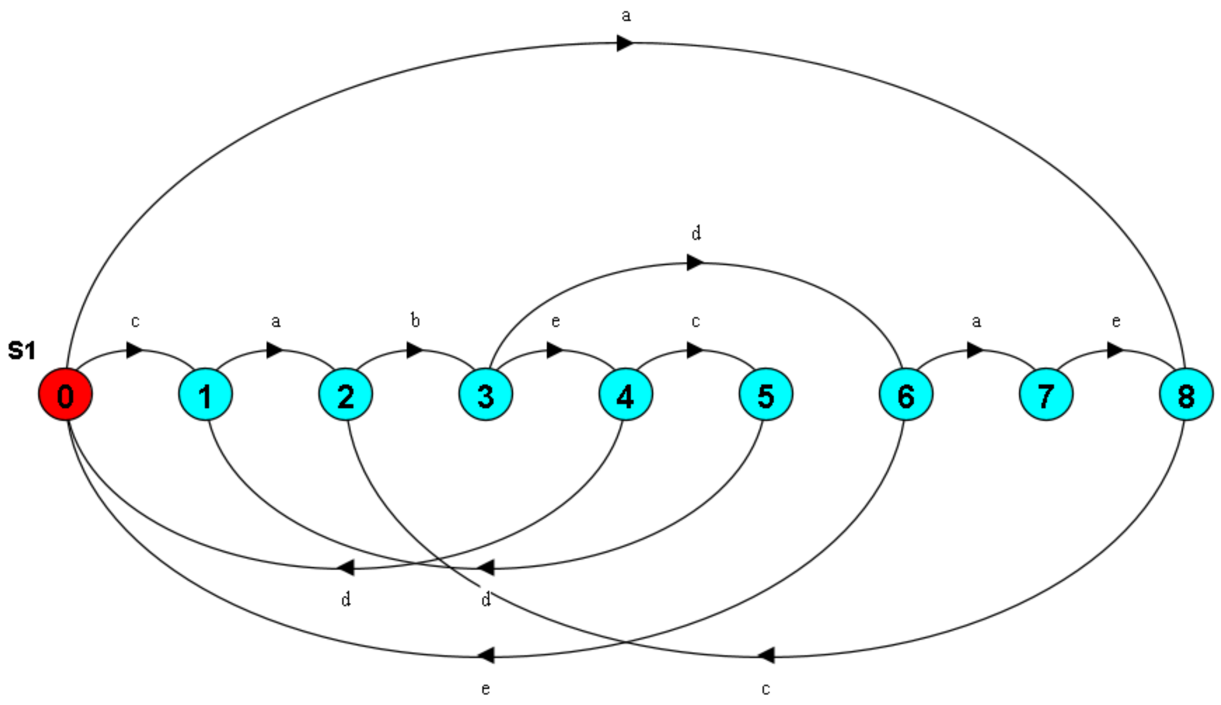




In N1, actions {a,c} and {d,e} can be executed simultaneously. N2 is isomorphic to LTS(||*S*1) = LTS(*S*2).

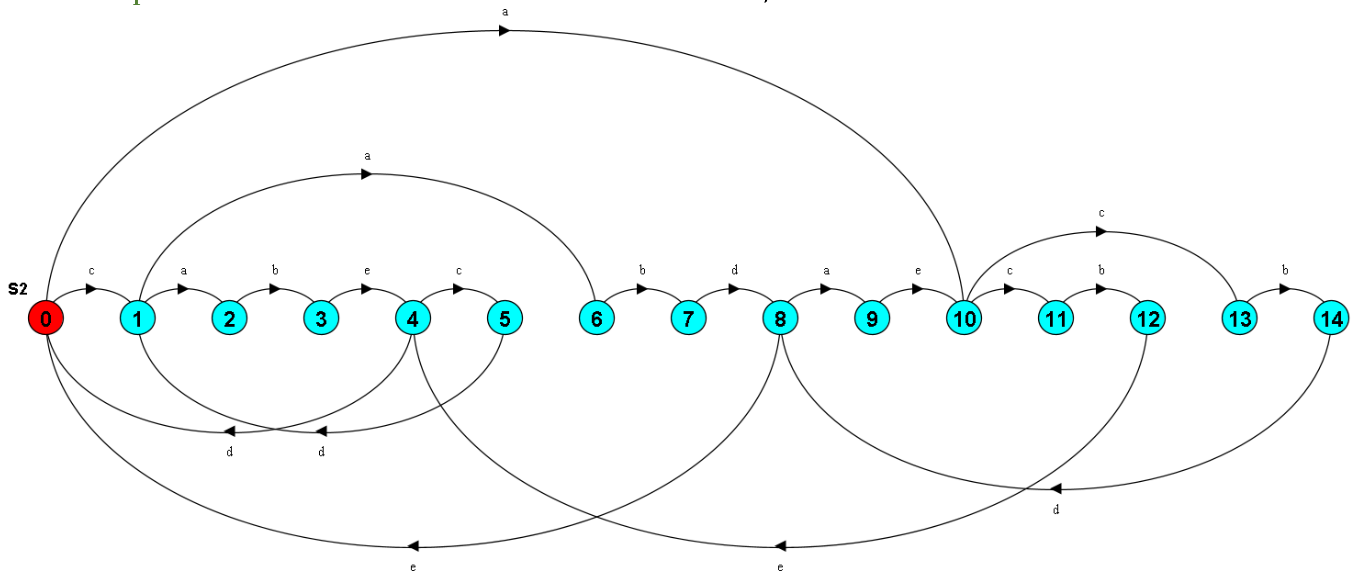
(Solution verification by LTSA tool)

```
P = (a -> b -> d -> P).
Q = (c -> b -> e -> Q).
|| S1 = (P || Q).
```

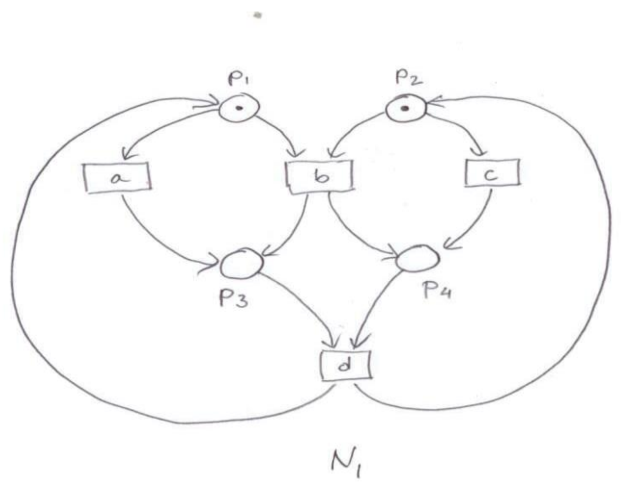


S2 = (a -> S2A | c -> S2B),
S2A = (c -> b -> d -> S2C | c -> b -> e -> S2D),
S2B = (a -> b -> d -> S2C | a -> b -> e -> S2D),
S2C = (e -> S2 | a -> e -> S2A),
S2D = (d -> S2 | c -> d -> S2B).

One example S1 = c -> a -> b -> e -> c -> d -> a -> b->e -> d -> S1,



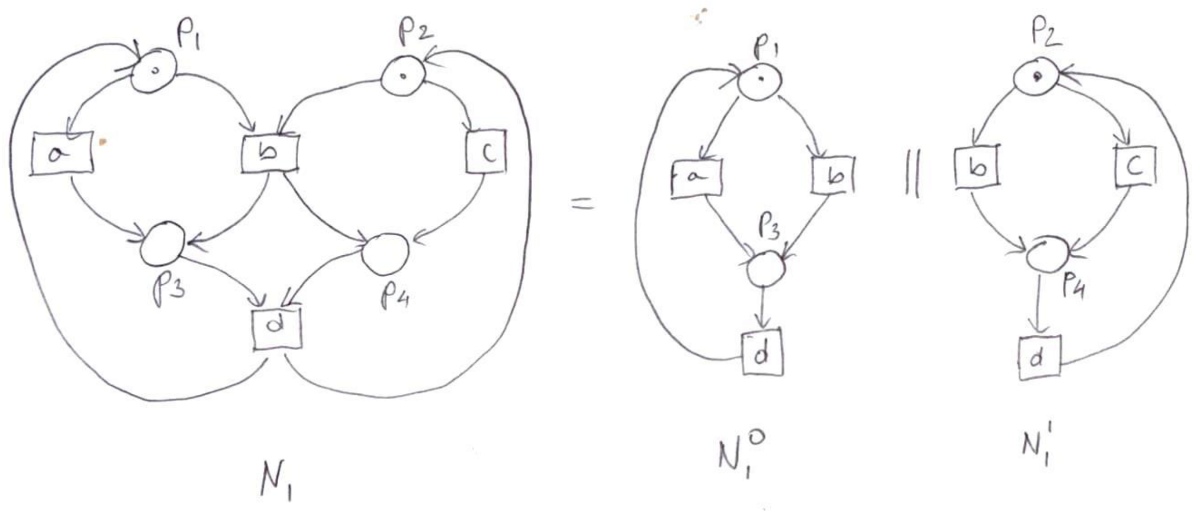
8.[10] Consider a Petri net below:



Model the net N_1 as a composition of *FSP* processes.

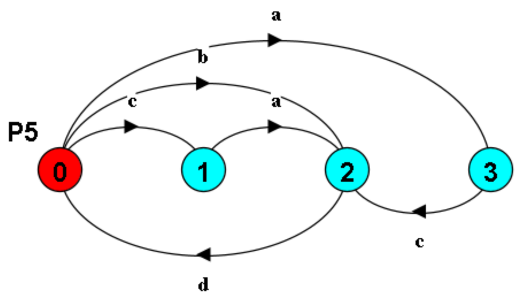
Solution:

Since we have:



a possible solution is:

```
P1 = (a -> P3 | b-> P3),
P3 = (d-> P1).
P2 = (b-> P4 | c-> P4),
P4 = (d-> P2).
||P5 = (P1 || P2).
```

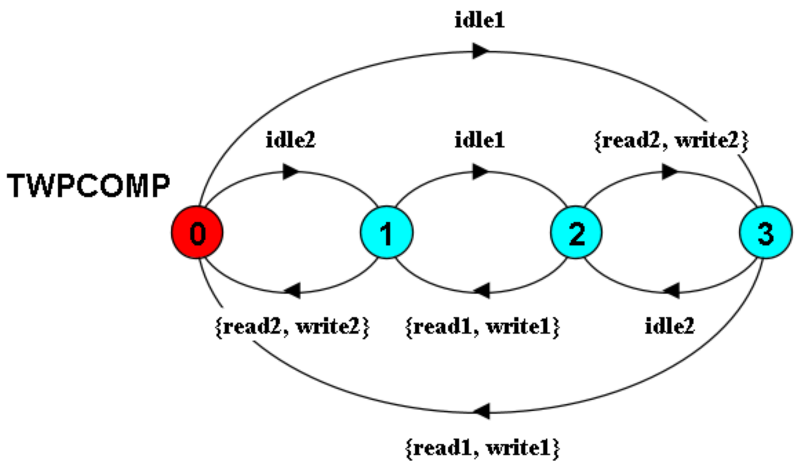


9.[10] Model the system from page 10 of Lecture Notes 3 as a composition of *FSP* processes. In this case, the entities that are represented by places in the Petri Nets model, must be represented by actions/transitions in *FSP* model.

Solution:

Solution: (a possible one, bonus for using labelling)

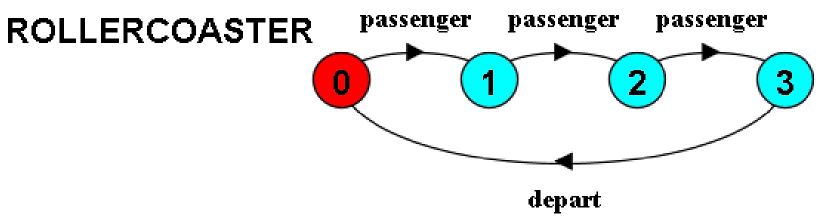
```
COMP1 = (idle1-> (read1-> COMP1| write1->COMP1)).
COMP2 = (idle2-> (read2-> COMP2| write2->COMP2)).
MUT = (write1->MUT|write2->MUT).
||TWPCOMP = (COMP1||COMP2||MUT).
```



10.[10] A roller-coaster control system only permits its car to depart when it is full. Passengers arriving at the departure platform are registered with the roller-coaster controller by a turnstile. The controller signals the car to depart when there are enough passengers on the platform to fill the car to its maximum capacity of *M* passengers. Ignore the synchronization detail of passengers embarking from the platform and car departure. The roller-coaster consists of three processes: *TURNSTILE*, *CONTROL* and *CAR*. *TURNSTILE* and *CONTROL* interact by the shared action *passenger* indicating an arrival and *CONTROL* and *CAR* interact by the shared action *depart* signalling the car departure. Provide FSP description for each process and the overall composition.

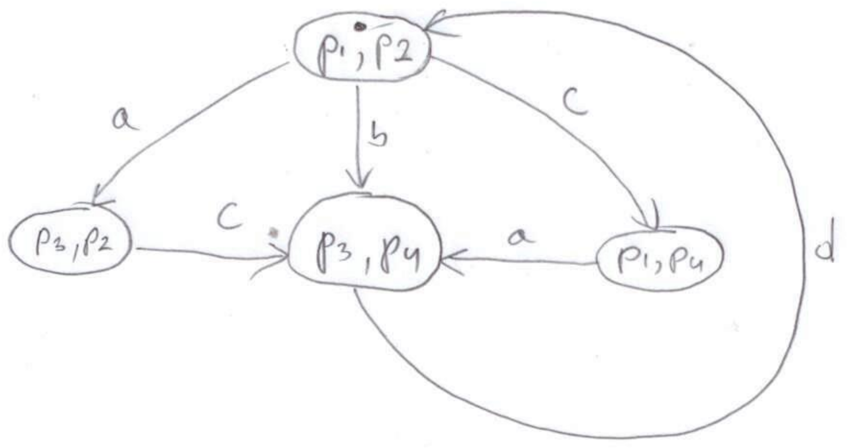
Solution (not unique):

```
const M = 3
TURNSTILE = (passenger -> TURNSTILE).
CONTROL       = CONTROL [0],
CONTROL [i:0..M] = (when (i<M) passenger -> CONTROL [i+1]
                |when (i==M) depart   -> CONTROL [0]).
CAR = (depart -> CAR).
||ROLLERCOASTER = (TURNSTILE || CONTROL || CAR).
```

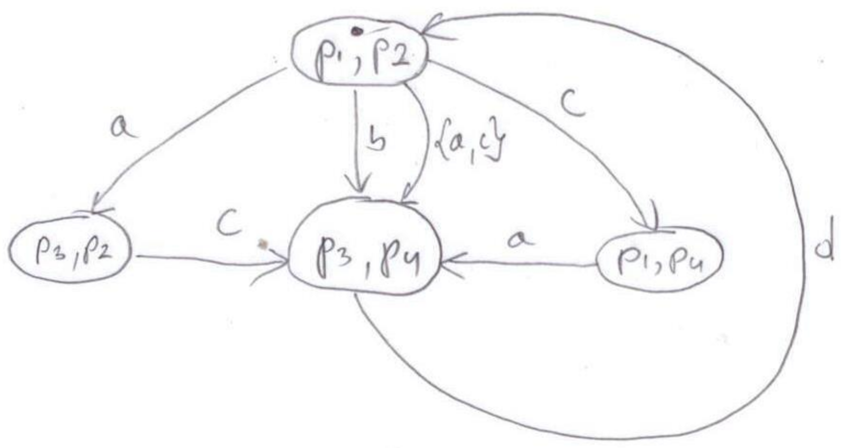


11.[10] Construct *reachability graph* (defined on page 18 of Lecture Notes 3) for the Petri net from Question 8.

Solution: (7 if simultaneity is not mentioned)



or, if simultaneity is allowed:



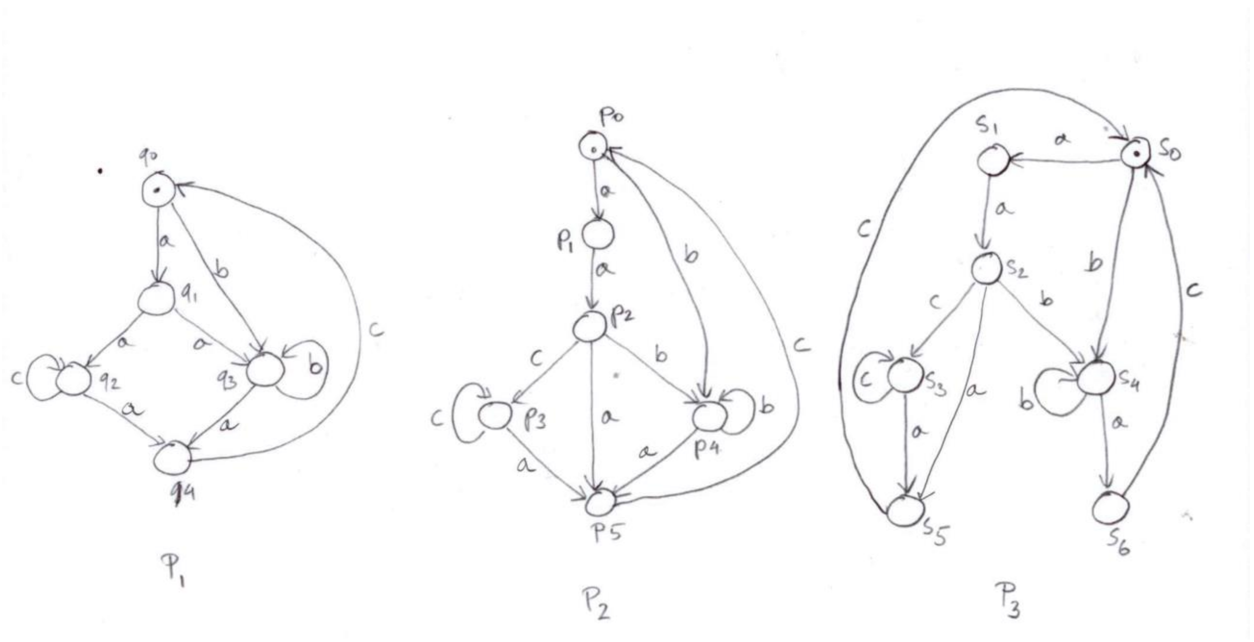
12.[28] Consider three Labelled Transition Systems (Finite State Machines, Finite Automata) given below: P_1, P_2 and P_3. Tokens represent initial states. Show that:

a.[8] $P_2 \approx P_3$, i.e. P_3 and P_3 are *bisimilar*,

b.[6] $P_1 \not\approx P_2$, i.e. P_1 and P_2 are *not bisimilar*,

c.[6] $P_1 \not\approx P_3$, i.e. P_1 and P_3 are *not bisimilar*,

d.[8] Traces(P_1) = Traces(P_2) = Traces(P_3) = Pref(*give a proper regular expression*).



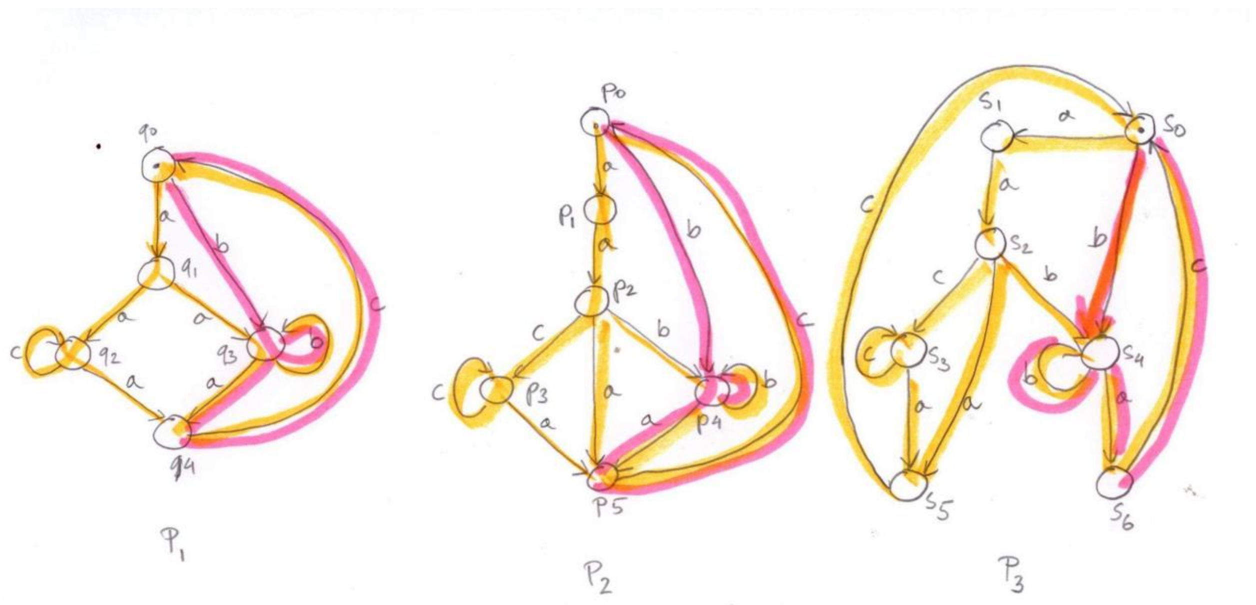
Solutions:

a. p_0 and s_0 are bisimilar as in both cases actions a and b are allowed.
   p_1 and s_1 are bisimilar as they both allow only a.
   p_2 and s_2 allow a, b and c, so they are bisimilar.
   p_3 and s_3 are bisimilar as they both allow a and c.
   p_4 and s_4 are bisimilar as they both allow a and b.
   p_5 and s_5 are bisimilar as they both allow only c, and
   p_5 and s_6 are also bisimilar as they also allow only c.
   We have exhausted all cases, so P_2 and P_3 are bisimilar, i.e. $P_2 \approx P_3$.

b. After trace aa the labeled transition system P_1 is either in the state q_2 or the state q_3, while P_2 is in the state p_2. In the state p_2 the actions a, b and c are allowed, in the state q_2 the actions a and c are allowed, while in the state q_3 the actions a and b are allowed. Hence both pairs (q_2,p_2) and (q_3,p_2) are *not* bisimilar, i.e. $P_1 \not\approx P_2$.

c. After trace aa the labeled transition system P_1 is either in the state q_2 or the state q_3, while P_3 is in the state s_2. In the state s_2 the actions a, b and c are allowed, in the state q_2 the actions a and c are allowed, while in the state q_3 the actions a and b are allowed. Hence both pairs (q_2,s_2) and (q_3,s_2) are *not* bisimilar, i.e. $P_1 \not\approx P_3$.

d.



Note that some parts are both yellow and red. In fact, only arrows $q_0 \rightarrow q_3$, $p_0 \rightarrow p_4$, $s_0 \rightarrow s_4$, labelled by b, are only red.

yellow(P_1) = aa(c* ∪ b*)ac   yellow(P_2) = aa(cc*a ∪ a ∪ bb*a)c = aa(c* ∪ b*)ac

yellow(P_3) = aa((cc*a ∪ a)c ∪ bb*ac) = aa(c* ∪ b*)ac

yellow = yellow(P_1) = yellow(P_2) = yellow(P_3)

yellow = aa(c* ∪ b*)ac   red = bb*ac

cycle = from q_0/ p_0/s_0 to q_0/ p_0/s_0 = (yellow ∪ red)*

Traces = Pref((yellow ∪ red)*) = Pref((aa(c* ∪ b*)ac) ∪ bb*ac)*)