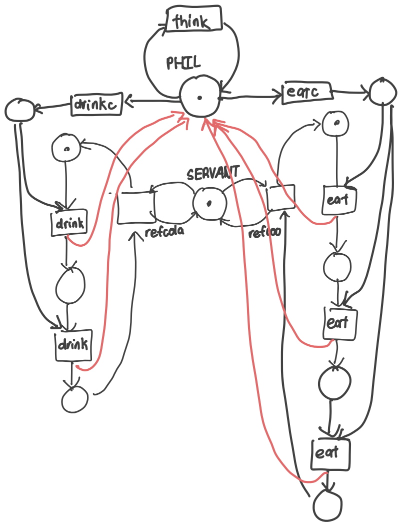
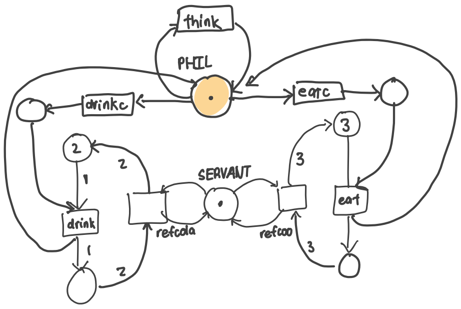
1)

a) LTSA

b) Cola machine has 2 drinks   1 Philosopher
Cookie machine has 3 cookies

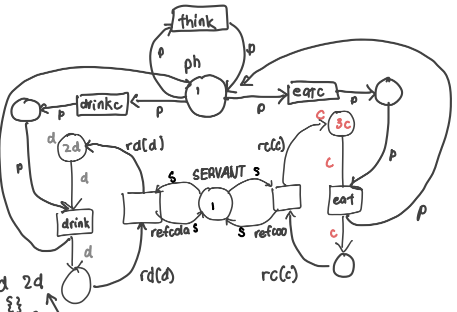


c)



Note: The part can be any value to represent any # of philosophers.

d) colour PHILSOPHERS= with phl
colour SERVANT = with s
colour COLAS = with d
colour COOKIES = with c
var p: PHILSOPHERS
var s: SERVANT
var c: COOKIES
var d: COLAS
var dl: Integer
var cl: Integer
dl = 0
cl = 0



rd: COLAS → {COLAS}^{p}
rc: COOKIES → {COOKIES}

```
func rd =  if rd+1=2
           then rd=0 and 2d
           | rd=rd+1 and {}

func rc =  if rc+1=3
           then rc=0 and 3c
           | rc=rc+1 and {}
```

return

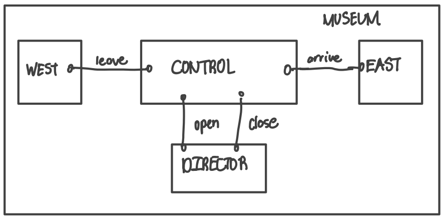
e) The main difference is that the FSP is not meant to show simultaneity, as it is NOT natural. With the elementary petri net, it shows every step b/c every transition only represents one drink or one cola. The P/T net uses numbers to condense down the elementary petri net. Finally, the colour net uses formulas and shows the calculations of each step.

f) JAVA

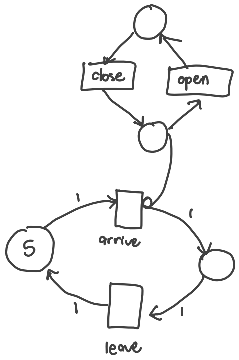
2)

a)
```
const N=5
EAST=(arrive→EAST).
WEST=(leave→WEST).
CONTROL=CLOSE [0],
CLOSE [i:0..N]=(when (i==0) open→OPEN[0]
               |when (i>0) leave→CLOSE[i-1]),

OPEN [i:0..N]=(close→CLOSE [i]
              |when( i<N) arrive→OPEN[i+1]
              |when (i>0) leave→OPEN[i-1]).


DIRECTOR=(open→close→DIRECTOR).
||MUSEUM=(CONTROL||EAST||WEST|| DIRECTOR     ).
```

c) CODED A2Q2



b) #of people: 5



3) 4 spots

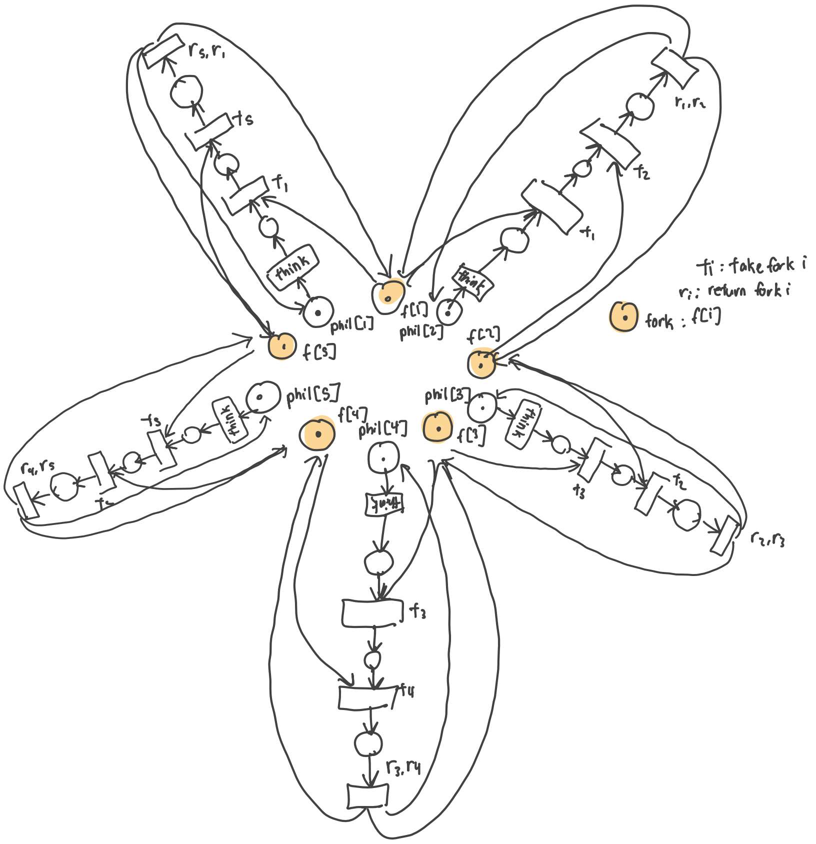
```
           const Max=4
           range Int=0..Max
           property SEMAPHORE(I=4)=SEMA[0],
safety   { SEMA [v:Int] = (arrive → SEMA[v+1]|
                          | depart →SEMA[v-1]).
           CHECK =(SEMA(4)|| CARPARK).

progress { progress ENTER={arrive}
           LIVE = CARPARK >> {depart}.
```

If depart has lower priority, then starvation can occur if you keep having cars arrive

4) From lecture slides

```
FORK=(take.right→put.right→FORK|
      take.left→put.left→FORK)
PHIL=(think→takeboth→eat→put both→PHIL)
||DINEAS(N=5)=forall[i:1..N]
  (phil[i]:PHIL||{phil[i].right,phil[i ⊕ 1].left}::FORK)
  /{takeboth.1/take.right.1, takeboth.1 /take.left.2,
    takeboth.2/take.right.2, takeboth.2 /take.left.3,
    takeboth.3/take.right.3, takeboth.3 /take.left.4,
    takeboth.4/take.right.4, takeboth.4 /take.left.5,
    takeboth.5/take.right.5, takeboth.5 /take.left.1,

    putboth.1/put.right.1 , putboth.1 / put.left.2,
    putboth.2/put.right.2 , putboth.2 / put.left.3,
    putboth.3/put.right.3 , putboth.3 / put.left.4,
    putboth.4/put.right.4 , putboth.4 / put.left.5,
    putboth.5/put.right.5 , putboth.5 / put.left.1}
```

5)

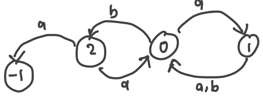


6) 10 people max

```
const Max=10
range Int=0..Max
  LIFT=(enter →exit →LIFT).
  SEMAPHORE(N=10     ) =SEMA [N],
  SEMA[v:Int]  =( enter    →SEMA[v+1]
                 |when (v>0) leave→SEMA[v-1]),

  SEMA[Max+1] =ERROR.
  ||SYS = (LIFT|| SEMAPHORE (10)).
```

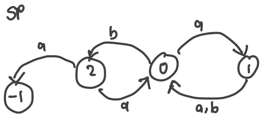
7) property P=(a→(b→P|a→P)| b→a→P)

P



SP= (a→(b→SP| a→SP)| b→(a→SP| b→ERROR))

SP



8)

a) LTSA

DEADLOCKS because:

AGENT_M puts down paper and tobacco (tt.deliver_match)
SMOKER_T takes paper (T.get_paper)
SMOKER_P takes tobacco (T.get_match)

Deadlocks b/c no resources AND no smoking.

b)
```
property CORRECT_PICKUP=( T. get_paper -> T. get_match -> CORRECT_PICKUP|
                          P. get_tobacco -> P. get_match -> CORRECT_PICKUP|
                          M. get_tobacco -> M. get_paper -> CORRECT_PICKUP)
```

```
||COMPOSED=(COMP|| CORRECT_PICKUP)
```

c) Changing smokers from part A. Assuming everything used in same way.

```
SMOKER_T= (no_tobacco  ->get_paper-> get_match -> roll_cigarrette ->
                smoke_cigarrette-> SMOKER_T);

SMOKER_P= (no_paper  ->get_tobacco-> get_match -> roll_cigarrette ->
                smoke_cigarrette-> SMOKER_P );

SMOKER_M= (no_matches ->get_tobacco -> get_paper -> roll_cigarrette ->
                smoke_cigarrette-> SMOKER_M),
```

d) Yes. This is b/c when each smoker checks if there is a lack of a specific item then they know it is their time to get the resources.

For example, if there is no tobacco on the table, the tobacco smoker knows it is their time to take the other two materials.

This is NOT violated with accordance to the textbook.

LTSA!!