Unit 2: NFA with ϵ-transitions

(Null moves)
It is an NFA including transitions on empty input i.e 'ϵ' (epsilon).

- Formal Definition:

NFA with null moves is denoted by a five-tuple $(Q, \Sigma, \delta, q_0, F)$.

Q: Finite set of states

Σ = finite input alphabet.

q_0 = Initial state contained in Q

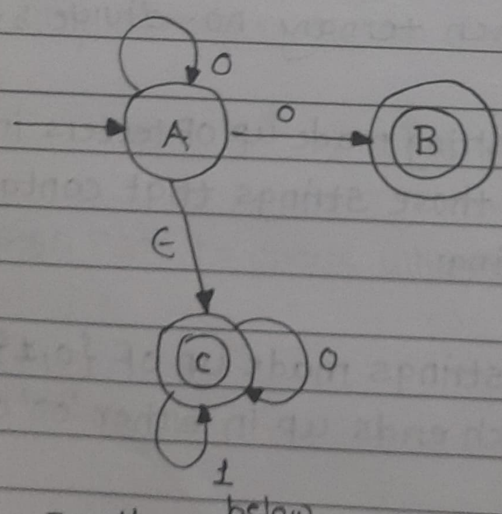
F = set of Final states

i.e $F \subseteq Q$

δ = ~~state~~ fun mapping from $Q \times (\Sigma \cup \{\epsilon\})$ to 2^Q

i.e $Q \times (\Sigma \cup \{\epsilon\}) \rightarrow 2^Q$

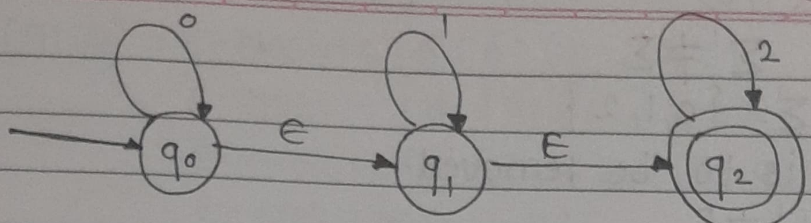
Ex1. The folln fig. shows that there is one transition from state 'A' to state 'C'.



In the ~~above~~ below fig. there is Null-transition from state $q_0 \rightarrow q_1$ and from state $q_1 \rightarrow q_2$

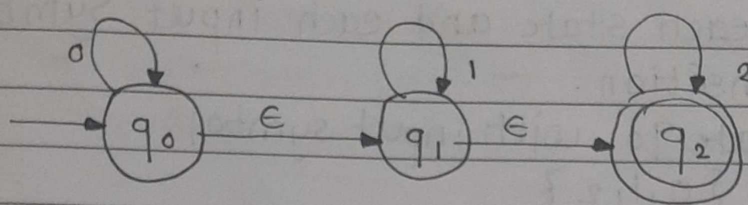
NFA - always contain Null moves

Page No.
Date



The meaning of Null transition means transition of empty input of length '0' (zero).

Construction of NFA with ϵ-moves to NFA without ϵ-moves to equivalent NFA without Null-moves.



ϵ- closure (q_0)
ϵ- closure (q_1)
ϵ- closure (q_2)

ϵ-closure of state is define as, set of states 'X' such that, there is part from present state to 'X' having label 'ϵ'

ϵ-closure (q_0) = all states with zero length from given state 'q_0'.
$= \{q_0, q_1, q_2\}$

ϵ- closure (q_1) $= \{q_1, q_2\}$

ϵ- closure (q_2) $= \{q_2\}$.

Ex. Given NFA with ϵ-moves is $M = (Q, \Sigma, q_0, f)$ Where

$Q = \{q_0, q_1, q_2\}$

$\Sigma = \{0, 1, 2\}$

q_0 = is initial state

$F = \{q_2\}$.

step 1: Assume Equivalent NFA without ϵ-moves

$M' = (Q', \Sigma', q_0', F', \delta')$

Where $Q' = Q = \{q_0, q_1, q_2\}$

Rule for finding state fun δ' of required NFA is $\delta'(q,a) = \epsilon\text{-closure}(\delta(\delta^T(q,\epsilon),a)$

$\delta^\wedge(q,\epsilon) = \epsilon\text{-closure}(q)$.

$\Sigma' \neq \Sigma$

i.e $\Sigma' = \{0,1,2\}$

'ϵ' is to be removed.

$F' \neq F$

i.e (calculated later)

~~$Q = Q'$~~

$\delta = Q \times \Sigma \rightarrow 2^Q$.

Step II: For each state and each input symbol find transition.

For state q_0 with input symbol

$\Sigma = \{0,1,2\}$

$\delta'(q_0,0) = \epsilon\text{-closure}(\delta(\delta^T(q_0,\epsilon),0)$

① $\delta'(q_0,0) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_0,\epsilon),0)$

$= \epsilon\text{-closure}(\delta(\{q_0,q_1,q_2\}),0)$

$= \epsilon\text{-closure}(\delta(q_0,0) \cup \delta(q_1,0) \cup \delta(q_2,0))$

$= \epsilon\text{-closure}(q_0 \cup - \cup -)$

$= \epsilon\text{-closure}(q_0)$

$\delta'(q_0,0) = q_0, q_1, q_2$

② $\delta(q_0,1) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_0,\epsilon),1)$

$= \epsilon\text{-closure}(\delta(\{q_0,q_1,q_2\}\},1)$

$= \epsilon\text{-closure}(\delta(q_0,1) \cup \delta(q_1,1) \cup \delta(q_2,1))$

$= \epsilon\text{-closure}(\cancel{q_1} - \cup q_1 \cup)$

$= \epsilon\text{-closure}(q_1)$

$\delta(q_0,1) = q_1, q_2$

③ $\delta(q_0,2) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_0,\epsilon),2)$

$= \epsilon\text{-closure}(\delta(\{q_0,q_1,q_2\}\},2)$

$= \epsilon\text{-closure}(\delta(q_0,2) \cup \delta(q_1,2) \cup \delta(q_2,2))$

$= \epsilon\text{-closure} \; - \cup - \cup - q_2)$

$= \epsilon\text{-closure}(q_2)$

$\delta(q_0,2) = q_2$.

ϵ $q_1 q_2$ q_2

(4) $\delta(q_1, 0) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_1, \epsilon), 0))$

$= \epsilon\text{-closure}(\delta.\{q_1, q_2\}, 0)$

$= \epsilon\text{-closure}(\delta(q_1, 0) \cup \delta(q_2, 0))$

$= \epsilon\text{-closure}(- \cup - \cup)$

$\boxed{\delta(q_1, 0) = \phi}$

(5) $\delta(q_1, 1) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_1, \epsilon), 1))$

$= \epsilon\text{-closure}(\delta\{q_1, q_2\}, 1)$

$= \epsilon\text{-closure}(q_1 - \cup)$

$= \epsilon\text{-closure}(q_1)$

$= q_1, q_2.$

(6) $\delta(q_1, 1) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_1, \epsilon), 2))$

$= \epsilon\text{-closure}(\delta\{q_1, q_2\}, 2)$

$= \epsilon\text{-closure}(q_2)$

$= q_2.$

(7) $\delta(q_2, 0) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_2, \epsilon), 0))$

$= \epsilon\text{-closure}(q_2, 0)$

$= q_2$

(8) $\delta(q_2, 1) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_2, \epsilon), 1))$

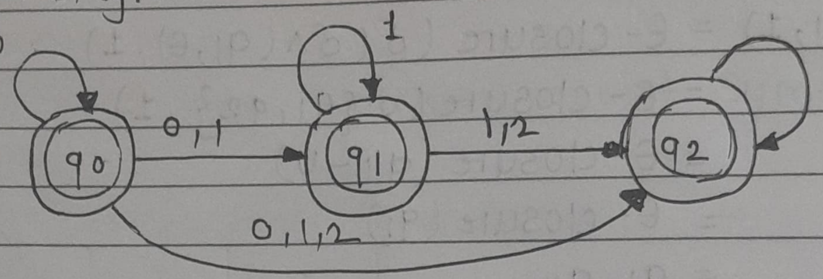
$= \phi$

(9) $\delta(q_2, 2) = \epsilon\text{-closure}(\delta(\delta^\wedge(q_2, \epsilon), 2))$

$= q_2$

$Q \backslash \Sigma$	0	1	2
q_0	$\{q_0, q_1, q_2\}$	$\{q_1, q_2\}$	$\{q_2\}$
q_1	ϕ	$\{q_1, q_2\}$	$\{q_2\}$
q_2	$\cancel{\{q_2\}}$ ϕ	ϕ	$\{q_2\}$

Transition Diagram:



In above, transition Diag. q_0 is final state because ϵ-closure (q_0) contains q_2 which is the final state of given NFA with Null moves.

q_1 is also final state because ϵ-closure (q_1) contains q_2 which is final state of given NFA with ϵ-moves. Similarly q_2 is also final state as per given NFA with ϵ-moves

Conversion of NFA to DFA:

Q.1. Convert NFA $M = (\{q_0, q_1\}, \{0, 1\}, \delta, \{q_0\}, \{q_1\})$ where δ is shown in below table. Equivalent to DFA.

$Q \backslash \Sigma$	0	1
q_0	$\{q_0, q_1\}$	$\{q_1\}$
q_1	ϕ	$\{q_0, q_1\}$

From given

① $A = q_0$

② $\delta(A, 0) = \delta(q_0, 0)$
$= q_0, q_1 - B$

③ $\delta(A, 1) = \delta(q_0, 1)$
$= q_1 — C$

④ $\delta(B, 0) = \delta(\{q_0, q_1\}, 0\}$
$= \delta(q_0, 0) \cup \delta(q_1 0)$
$= q_0, q_1 \cup \phi$
$= B.$

⑤ $\delta(B, 1) = \delta(q_0, 1) \cup \delta(q_1, 1)$
$= q_1 \cup \{q_0, q_1\}$
$= q_0 q_1$

⑥ $\delta(C, 0) = \delta(q_1, 0)$
$= \phi$

⑦ $\delta(C, 1) = \delta(q_1, 1)$
$= q_0, q_1 - B.$

Q \ Σ	0	1
A	B	C
B	B	B
C	ϕ	B

Q \ Σ	0	1
$\{q_0\}$	$\{q_0, q_1\}$	$\{q_1\}$
$\{q_0, q_1\}$	$\{q_0, q_1\}$	$\{q_0, q_1\}$
$\{q_1\}$	ϕ	$\{q_0, q_1\}$

Q.2 Convert NFA $M = (\{q_0, q_1, q_2\}, \{a, b\}, \delta, q_0, \{q_2\})$ where δ is shown in below table to an equivalent DFA.

S \ Σ	a	b
q_0	$\{q_0 q_1\}$	$\{q_2\}$
q_1	$\{q_0\}$	$\{q_1\}$
q_2	–	$\{q_0 q_1\}$

let DFA $= (\{A, B, C \dots F\}, \{0, 1\}, \delta, A, \{F\})$

From given

① $A = q_0$.

② $\delta(A, a) = \cancel{\delta(q_0, a)}$
$= \{q_0 q_1\}$ — B

③ $\delta(A, b) = \delta(q_0, b)$
$= q_2$ — C

④ $\delta(B, a) = \delta(q_0 q_1), a$
$= \delta(q_0, a) \cup \delta(q_1, a)$
$= q_0, q_1 \cup q_0$
$= q_0 q_1$ — B.

(5) $\delta(B, b) = \delta((q_0, q_1), b)$
$= \delta(q_0, b) \cup \delta(q_1, b)$
$= q_2 \cup q_1$
$= q_2 q_1$ — D

(6) $\delta(C, a) = \delta(q_2, a)$
$= -$

(7) $\delta(C, b) = \delta(q_2, b)$
$= q_0 q_1$ — B

(8) $\delta(D, a) = \delta((q_2, q_1), a)$
$= \delta(q_2, a) \cup \delta(q_1, a)$
$= - \cup q_0$
$= q_0.$
$= A.$

(9) $\delta(D, b) = \delta((q_2, q_1), b)$
$= q_0 q_1 \cup q_1$
$= q_0 q_1$ — B.

S \ Σ	a	b
A	B	C
B	~~A~~ B	D
C	–	B
D	~~q_0~~ A	B

S \ Σ	a	b
$\{q_0\}$	$\{q_0 q_1\}$	$\{q_2\}$
$\{q_0, q_1\}$	$\{q_0, q_1\}$	$\{q_2, q_1\}$
$\{q_2\}$	–	$\{q_0 q_1\}$
$\{q_2 q_1\}$	$\{q_0\}$	$\{q_0 q_1\}$

Q. Construct DFA equivalent to $M = (\{q_0, q_1, q_2, q_3\}, \{a, b\}, \delta, q_0, \{q_3\})$
Where δ is given below table.

$S \backslash \Sigma$	a	b
$\{q_0\}$	$\{q_0, q_1\}$	q_0
$\{q_1\}$	$\{q_2\}$	$\{q_1\}$
$\{q_2\}$	$\{q_3\}$	$\{q_3\}$
q_3	-	$\{q_2\}$

let DFA $= (\{A, B, C \ldots F\}, \{a, b\}, \delta, A, \{F'\})$.

soln: from given

① $A = q_0$

② $\delta(A, a) = \delta(q_0, a)$
$= q_0 q_1$ — B

③ $\delta(A, b) = \delta(q_0, b)$
$= q_0$ — A

④ $\delta(B, a) = \delta((q_0, q_1), a)$
$= \delta(q_0, a) \cup \delta(q_1, a)$
$= q_0 q_1 \cup q_2$
$= q_0 q_1 q_2$ — C.

⑤ $\delta(B, b) = \delta((q_0, q_1), b)$
$= \delta(q_0, b) \cup \delta(q_1, b)$
$= q_0 \cup q_1$
$= q_0 q_1$ — B

⑥ $\delta(C,a) = \delta(q_0q_1q_2), a)$
$= \delta(q_0,a) \cup \delta(q_1,a) \cup \delta(q_2,a)$
$= q_0,q_1 \cup q_2 \cup q_3$
$= q_0,q_1,q_2,q_3$ — D

⑦ $\delta(C,b) = \delta(q_0q_1q_2), b)$
$= \delta(q_0,b) \cup \delta(q_1,b) \cup \delta(q_2,b)$
$= q_0 \cup q_1 \cup q_3$
$= q_0q_1q_3$ — E

⑧ $\delta(D,a) = \delta(q_0,q_1,q_2,q_3), a)$
$= \delta(q_0,a) \cup \delta(q_1,a) \cup \delta(q_2,a) \cup \delta(q_3,a)$
$= q_0,q_1 \cup q_2 \cup q_3$ —
$= D$

⑨ $\delta(D,b) = \delta(q_0,q_1,q_2,q_3), b)$
$= \delta(q_0,b) \cup \delta(q_1,b) \cup \delta(q_2,b) \cup \delta(q_3,b)$
$= q_0 \cup q_1 \cup q_3 \cup q_2$
$= D$

⑩ $\delta(E,a) = \delta(q_0,q_1,q_3), a)$
$= \delta(q_0,a) \cup \delta(q_1,a) \cup \delta(q_3,a)$
$= q_0q_1 \cup q_2$
$= q_0q_1q_2$ — C

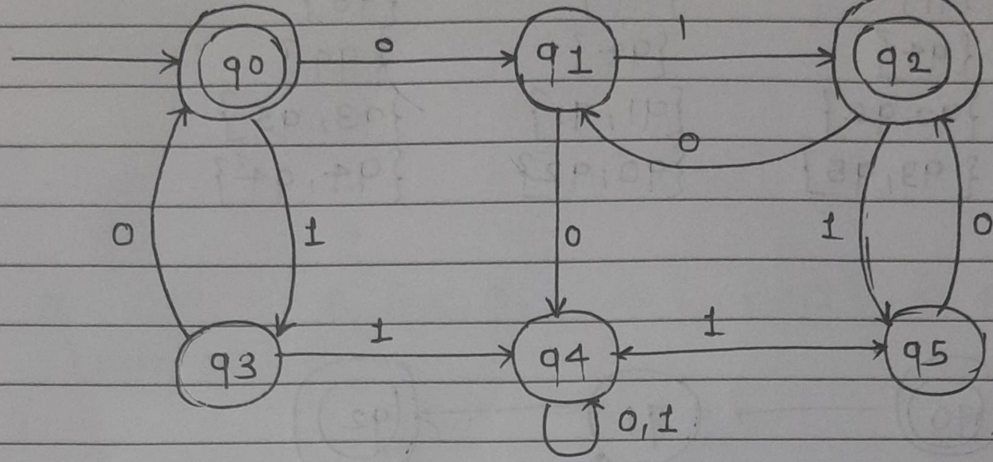
⑪ $\delta(E,b) = \delta(q_0,q_1,q_3), b)$
$= \delta(q_0,b) \cup \delta(q_1,b) \cup \delta(q_3,b)$
$= q_0 \cup q_1 \cup q_2$
$= C.$

$S \setminus \Sigma$	a	b
A	B	A
B	C	B
C	D	E
D	D	D
E	C	C

$S \setminus \Sigma$	a	b
$\{q_0\}$	$\{q_0 q_1\}$	$\{q_0\}$
$\{q_0, q_1\}$	$\{q_0 q_1 q_2\}$	$\{q_0 q_1\}$
$\{q_0, q_1, q_2\}$	$\{q_0 q_1 q_2 q_3\}$	$\{q_0 q_1 q_3\}$
$\{q_0, q_1, q_2, q_3\}$	$\{q_0 q_1 q_2 q_3\}$	$\{q_0 q_1 q_2 q_3\}$
$\{q_0, q_1, q_3\}$	$\{q_0 q_1 q_2\}$	$\{q_0 q_1 q_2\}$

- Minimization of FSM:

Q. Construct minimum state automaton described by Foll^n Transition Diagram.



Sol^n:

$S \backslash \Sigma$	0	1
(q_0)	q_1	q_3
q_1	q_4	q_2
(q_2)	q_1	q_5
q_3	q_0	q_4
q_4	q_4	q_4
q_5	q_2	q_4

$\pi_0 = \{ \{q_0, q_2\}, \{q_1, q_3, q_4, q_5\} \}$

$\pi_1 = \{ \{q_0, q_2\} \{q_1\} \{q_3, q_5, q_4\} \}$

$\pi_2 = \{ \{q_0, q_2\}, \{q_1\} \{q_3, q_5\}, \{q_4\} \}$

Q. convert NFA $(\{p,q,r,s\},\{0,1\},\delta,p,\{s\})$ to its equivalent dfa where δ is shown in below table.

Q/E	0	1
p	p, q	p
q	r	r
r	s	–
(s)	s	s

let DFA = $\{A,B,C,D,\ldots F\},\{0,1\},\delta,p,\{s\}\}$.

From given

① $A = p$.

② $\delta(A,0) = \delta(p,0)$

$= p,q$ — B

③ $\delta(A,1) = \delta(p,1)$

$= p$ — A

④ $\delta(B,0) = \delta((p,q),0)$

$= \delta(p,0) \cup \delta(q,0)$

$= p,q \cup r$

$= p,q,r$ — C

⑤ $\delta(B,1) = \delta((p,q),1)$

$= \delta(p,1) \cup \delta(q,1)$

$= p \cup r$

$= p,r$ — D.

⑥ $\delta(C,0) = \delta((p,q,r),0)$

$= \delta(p,0) \cup \delta(q,0) \cup \delta(r,0)$

$= p,q \cup r \cup s$

$= p,q,r,s$ — E

⑦ $\delta(C,1) = \delta((p,q,r),1)$
$= \delta(p,1) \cup \delta(q,1) \cup \delta(r,1)$
$= p \cup r \cup -$
$= p, r$ — D.

⑧ $\delta(D,0) = \delta((p,r),0)$
$= \delta(p,0) \cup \delta(r,0)$
$= p,q \cup s$
$= p,q,s$ — F.

⑨ $\delta(D,1) = \delta((p,r),1)$
$= \delta(p,1) \cup \delta(r,1)$
$= p \cup -$
$= p$ — A

⑩ $\delta(E,0) = \delta((p,q,r,s)),0)$
$= \delta(p,0) \cup \delta(q,0) \cup \delta(r,0) \cup \delta(s,0)$
$= p,q, \cup r \cup s \cup s$
$= p,q,r,s$ — E.

⑪ $\delta(E,1) = \delta((p,q,r,s),1)$
$= \delta(p,1) \cup \delta(q,1) \cup \delta(r,1) \cup \delta(s,1)$
$= p,r,s$ — G

⑫ $\delta(F,0) = \delta(S,0) = \phi$.
δ

⑬ $\delta(F,1) = \delta(S,1) = p$ — Ⓐ

Q/e	0	1
A	B	C
B	D	E
Ⓒ	E	B
Ⓓ	F	A
E	F	A
Ⓕ	ϕ	A

Q/e	0	1
{p}	{q,r}	{q}
{q,r}	{r,s}	{r}
{q}	{r}	{q,r}
{rs}	{s}	{p}
{r}	{s}	{p}
{s}	—	{p}

Date

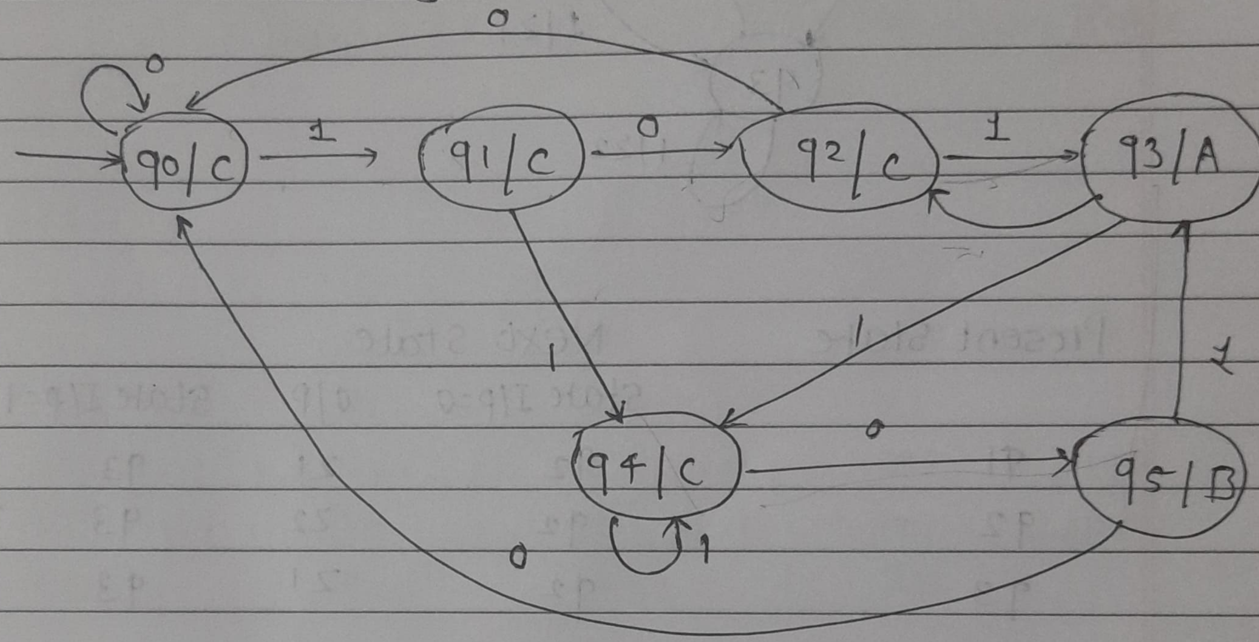
Design Moore and Mealy for binary input sequence if it end with 101 outputs A and if ends with 110 output B otherwise C.

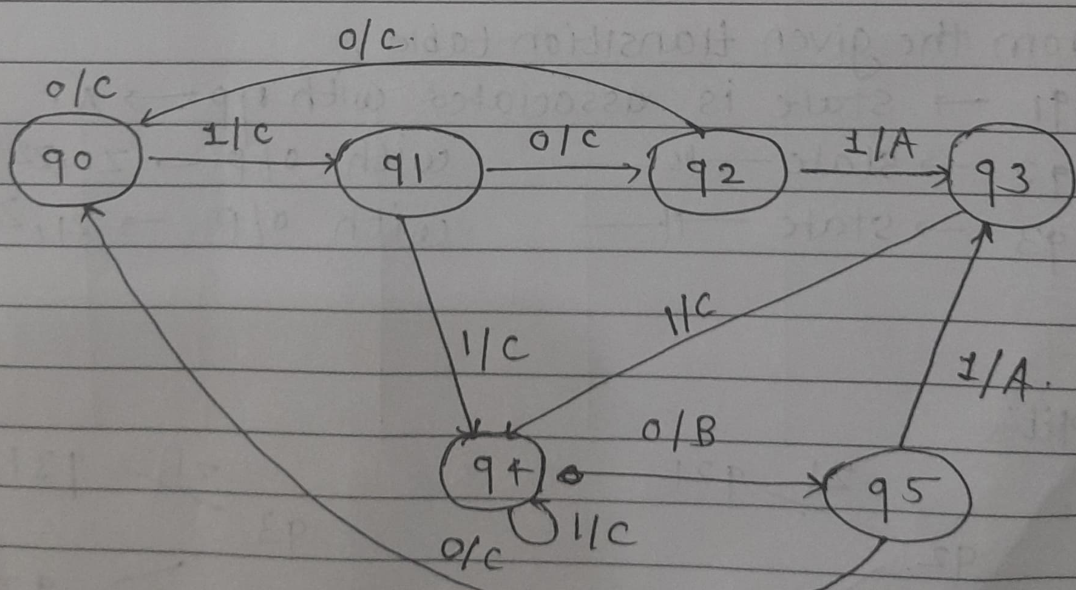
Soln:

In above given problem

$\Sigma = \{\{101\}, \{110\}\}$.

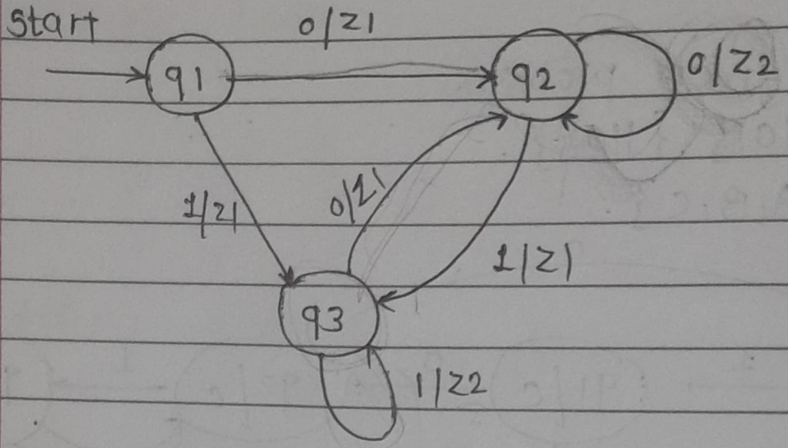
$\Delta = \{A, B, C\}$.





Mealy Diagram.

Q. construct moore machine equivalent to Mealy machine given below.



Present State	Next State			
	State I/P=0	O/P	State I/P=1	O/P
q1	q2	z1	q3	z1
q2	q2	z2	q3	z1
q3	q2	z1	q3	z2

From the given transition table,
q1 → state is associated with o/p → λ.
q2 → state — " — with o/p → z1, z2
q3 → state — " — with o/p → z1, z2

Split:

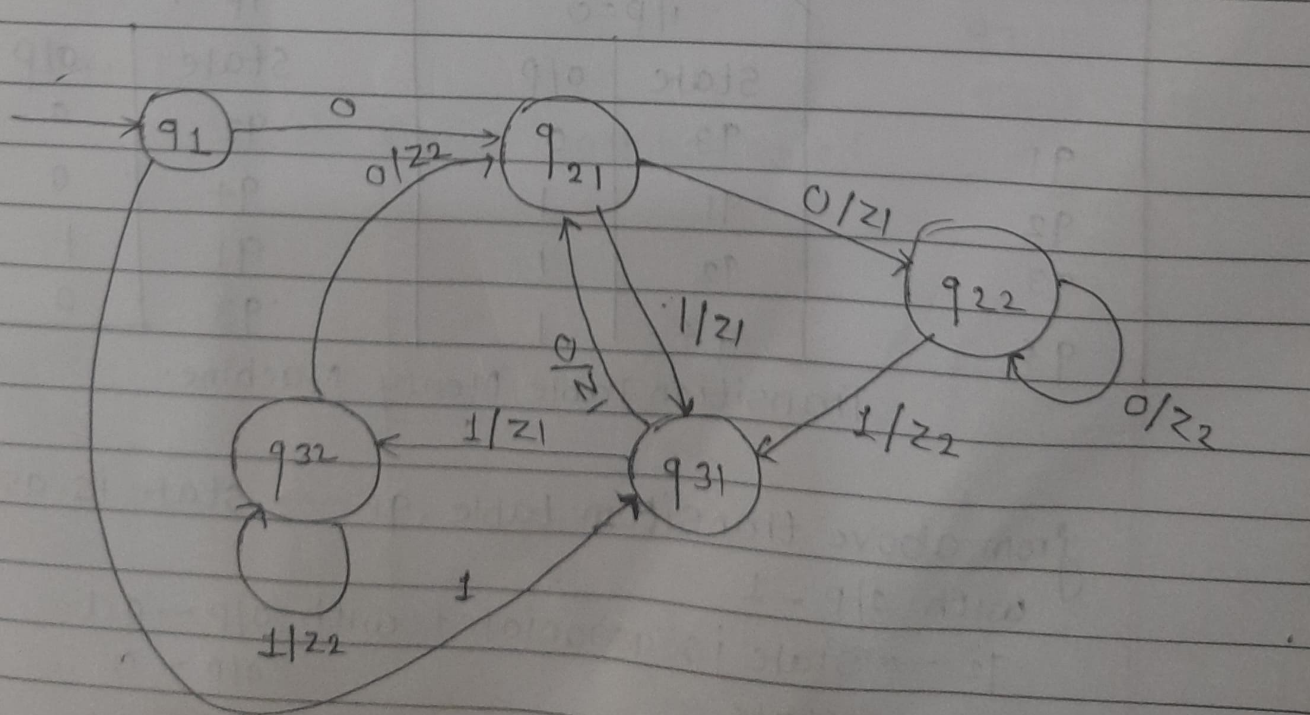
q2: z1 → q21, z2 → q22

q3: z1 → q31, z2 → q32

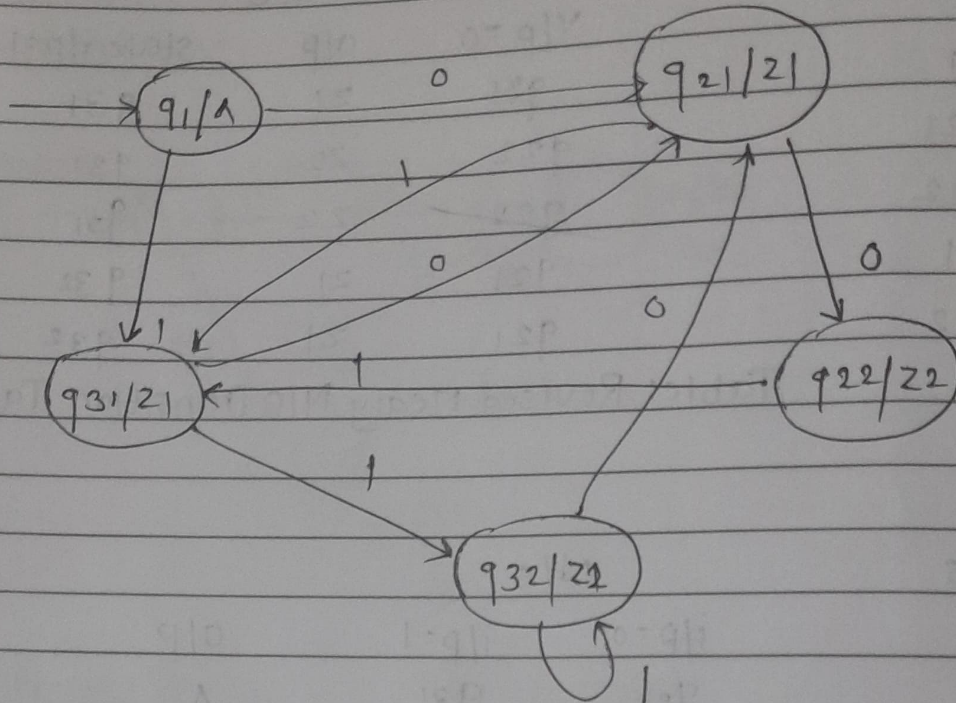
Present State	Next State			
	i/p = 0	o/p	State i/p = 1	o/p
q_1	q_{21}	z_1	q_{31}	z_1
q_{21}	q_{22}	z_2	q_{31}	z_1
q_{22}	q_{22}	z_2	q_{31}	z_1
q_{31}	q_{21}	z_1	q_{32}	z_2
q_{32}	q_{21}	z_1	q_{32}	z_2

Table: Revised Mealy M/C Transition Table

P/S	N/S		
	i/p = 0	i/p = 1	o/p
q_1	q_{21}	q_{31}	$\wedge$
q_{21}	q_{22}	q_{31}	z_1
q_{22}	q_{22}	q_{31}	z_2
q_{31}	q_{21}	q_{32}	z_1
q_{32}	q_{21}	q_{32}	z_2



Moore Diagram.



Q. Consider Mealy machine describe by given transition table. consider moore machine which eq. to mealy machine

Present state	Next state			
	i/p = 0		i/p = 1	
	State	o/p	State	o/p
q_1	q_3	0	q_2	0
q_2	q_1	1	q_4	0
q_3	q_2	1	q_1	1
q_4	q_4	1	q_3	0

Transition Table Mealy Machine.

from above transition table, $q_1 \rightarrow$ state is associated with o/p - 1

$q_2 \rightarrow$ state is associated with o/p – 0,1

$q_3 \rightarrow$ state o/p – 0

q_4 o/p – 0,1

As q_2 & q_4 state having two outputs 0 & 1.

∴ Split

$q_2 \xrightarrow{0} q_{20}$

$q_2 \xrightarrow{1} q_{21}$

$q_4 \xrightarrow{0} q_{40}$

$q_4 \xrightarrow{1} q_{41}$

Present state	Next state i/p=0	o/p	i/p=1	o/p
q_1	q_3	0	q_{20}	0
q_{20}	q_1	1	q_{40}	0
q_3	q_{21}	1	q_1	1
q_{21}	q_1	1	q_{40}	0
q_{40}	q_{41}	1	q_3	0
q_{41}	q_{41}	1	q_3	0

Revised Mealy Machine Table.

P/S	N/S i/p=0	i/p=1	o/p
→ q_1	q_3	q_{20}	1
q_{20}	q_1	q_{40}	0
q_{21}	q_1	q_{40}	1
q_3	q_{21}	q_1	0
q_{40}	q_{41}	q_3	0
q_{41}	q_{41}	q_3	1

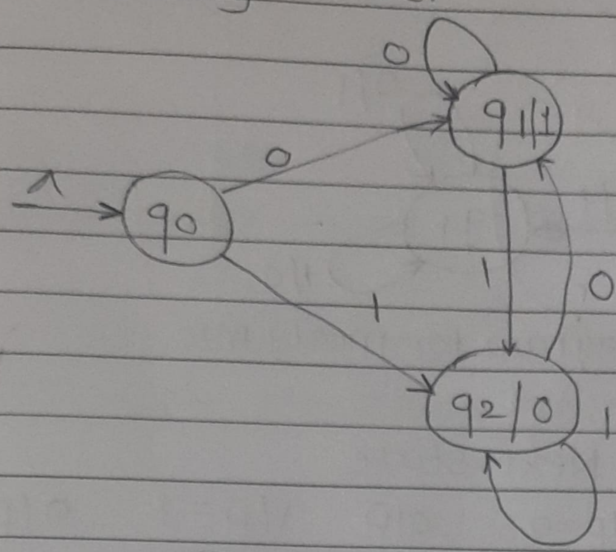
Trans. Table Moore M/C.

In above table of moore machine, the initial state q1 is associated with output → 1.
this means that with input → 'Λ'. we get an output of 1. if the machine starts at state q1.
Thus, this moore machine accept zero length sequence (Null sequence) which is not accepted the mealy machine.
To overcome this situation, either we must neglect the response of moore machine to input 'Λ'. or we must add new starting state q_0 whose state transition are identical with those of q1. But whose output is 0.

PS	NS i/p=0	NS ip=1	o/p
q_0	q_3	q_{20}	0
q_1	q_3	q_{20}	1
q_{20}	q_1	q_{40}	0
q_{21}	q_1	q_{40}	1
q_3	q_{21}	q_1	0
q_{40}	q_{41}	q_3	0
q_{41}	q_{41}	q_3	1

Revised Moore Machine Diagram.

Q. Design moore machine generate one's complement of given binary number.



Transition Diagram for moore ~~dia~~ m/c.

Ps	NS i/p=0	NS i/p=1	o/p
q0	q1	q2	0
q1	q1	q2	1
q2	q1	q2	0

Transition for moore m/c.

For ex. take binary i/p as 101

state → i/p → Next state → o/p

q0 → 1 → q2 → 0

q2 → q1 → 1

→ q2 → 0

q1

q0 → 1 → q2 → 0   q1 → 1 → q2 → 0.

q2 → 0 → q1 → 1

Q. Design mealy machine 2's complement of given binary number.

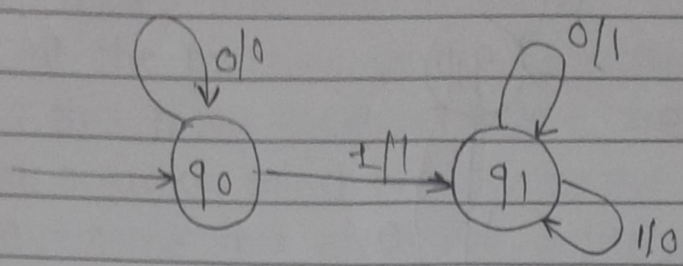


Fig. Tran. diagram for mealy m/c

Present state	Next state i/p = 0	o/p	i/p = 1	o/p.
q_0	q_0	0	q_1	1
q_1	q_1	1	q_1	0

Fig. Transition Table for mealy m/c

For ex. take binary i/p as 1010

PS

$q_0 \xrightarrow{0} q_0$

$q_0 \xrightarrow{1} q_1$

$q_1 \xrightarrow{0} q_1$

$q_1 \xrightarrow{1} q_1$

Read it from bottom to top.

$\Rightarrow$ 0110.

Date

Q. Design Mealy machine one's complement of given binary no.

Soln:

Q. Design Moore machine to determine the residue (Remainder) mod 3 for binary number.

Q. Consider moore machine equivalent mealy machine define by the below table.

PS	NS			
	a=0		a=1	
	state	o/p	state	o/p.
$\rightarrow q_1$	q_1	1	q_2	0
q_2	q_4	1	q_4	1
q_3	q_2	1	q_3	1
q_4	q_3	0	q_1	1

Q. Explain equivalence of two FSM.

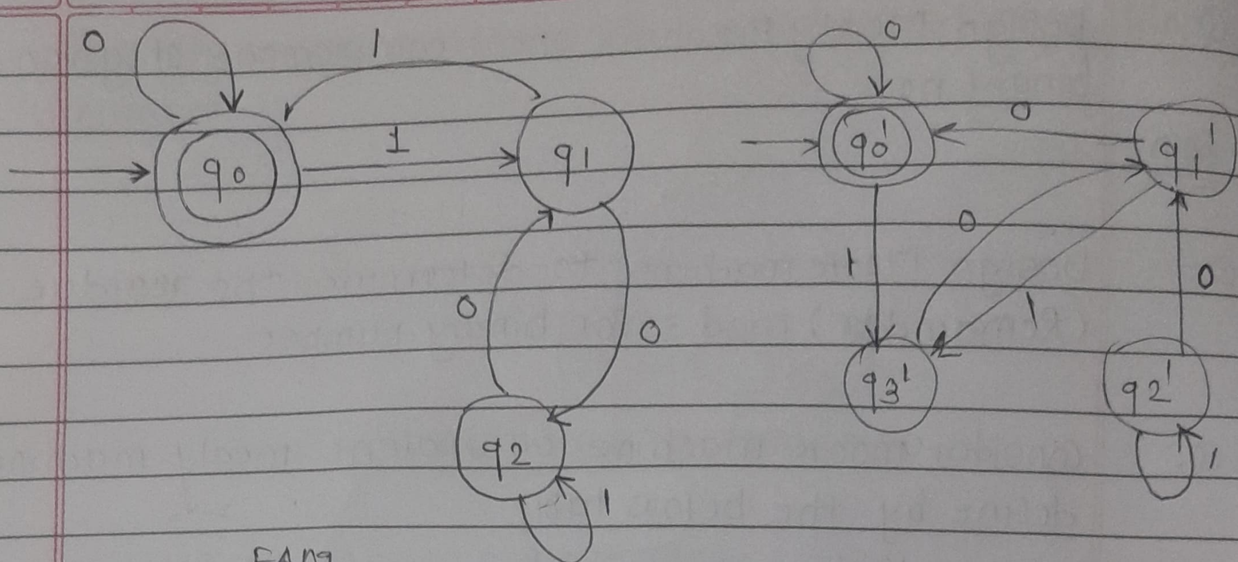
OR.

Explain Moore's Algorithm for FSM equivalence.

Page no.-158

5·13 & 5·16.

Q. Consider the Folln two DFA M and M' over {0,1} given in below Fig. Determine whether M and M' are equivalent.



FA M.

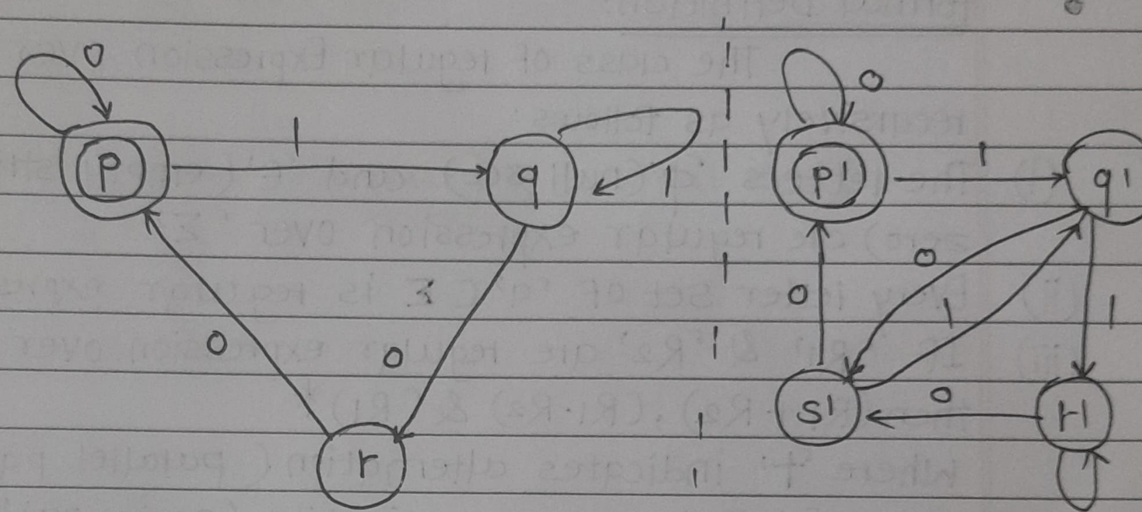
For given FA's $\Sigma = \{0,1\}$ i.e $|\Sigma| = 2 = n$.
∴ It is necessary to create n+1 columns labelled so $n+1 = 2+1 = 3$.
∴ We have to create three columns labelled. (V, V'), (V_0, V_0') & (V_1, V_1').
Below table shows comparisons betn M and M'

(V, V')	(V_0, V_0')	(V_1, V_1')
(q_0, q_0')	(q_0, q_0')	(q_1, q_3')
(q_1, q_3')	(q_2, q_1')	(q_0, q_2')

As we start with (q_0, q_0') now ~~ze~~ 0 intput symbol it goes to (q_0, q_0') where these are final states and on 1 intput symbol it goes (q_1, q_3') both are non-final state.
∴ We can proceed for new column which is not there i.e (q_1, q_3') place it in the column 1, repeat the procedure for state (q_1, q_3') for i/p symbol '0' it goes to (q_2, q_1') both are non-final state. But for input symbol '1' (q_1, q_3') it goes to (q_0, q_2') here q_0 = final state of M &
q_2' = Non-final state of M'.

∴ We have to stop & declare that the given two FSM's M and M' are not equivalent.

Q. Consider the folln two DFA's M and M' over {0,1} given in below Fig. Determine whether M and M' are equivalent



$\Sigma = \{0,1\}$

i.e $|\Sigma| = 2 = n$

∴ We have to create three columns labelled.

(V, V'), (V0, V0') & (V1, V1')

Below table shows comparison betn M and M'

(V, V')	(V0, V0')	(V1, V1')
(p, p')	(p, p')	(q, q')
(q, q')	(r, s')	(q, r')
(q, r') (r, s')	(r, s') (p, p')	(q, r') (q, r')

As we start with (p, p') now '0' input symbol it goes to (p, p') where these are final states. and on 1 input symbol it goes (q, q') both are non-final state.

∴ We