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CSE-B
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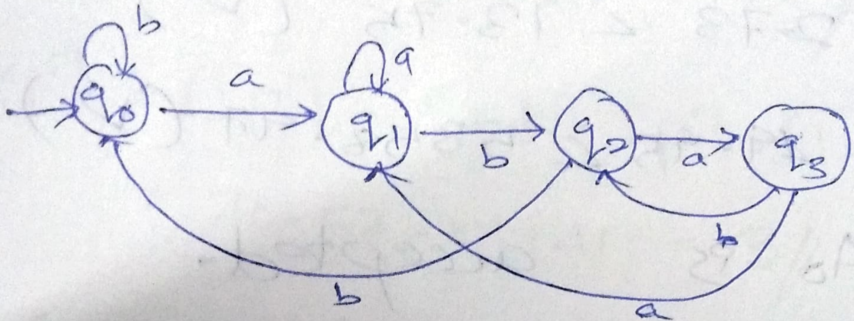
Theory of Computations

(1) $L = \{aba, aaba, baba \ldots\}$

DFA transition diagram



Transition Table

δ	a	b
q_0	q_1	q_0
q_1	q_1	q_2
q_2	q_3	q_0
q_3	q	q_2

Checking for (i) bbabab

$F(q_0, b) = q_0$

$F(q_0, b) = q_0$

$F(q_0, a) = q_1$

$f(q_1, b) = q_2$

$f(q_2, a) = q_3$

$\delta(q_3, b) = q_2$

Not satisfied.

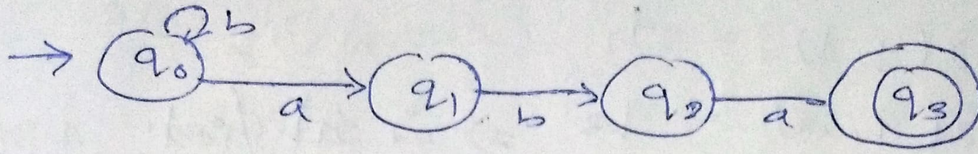
(ii) baba

$\delta(q_0, b) = q_0$ | $\delta(q_0, a) = q_1$

$\delta(q_1, b) = q_2$ | $\delta(q_2, a) = q_2$

It is satisfied.

NFA diagram:



(i) bbabab

$\delta(q_0, b) = q_0$

$\delta(q_0, b) = q_0$

$\delta(q_1, a) = \{q_0, q_1\}$

$\delta(\{q_0, q_1\} b) = \{q_0, q_2\}$

$\delta(\{q_0, q_2\}, a) = \{q_0, q_1, q_3\}$

$\delta(\{q_0, q_1, q_3\} b) = \{q_0, q_2, \phi\}$

$\therefore$ not satisfied

(ii) baba

$\delta(q_0, b) = q_0$

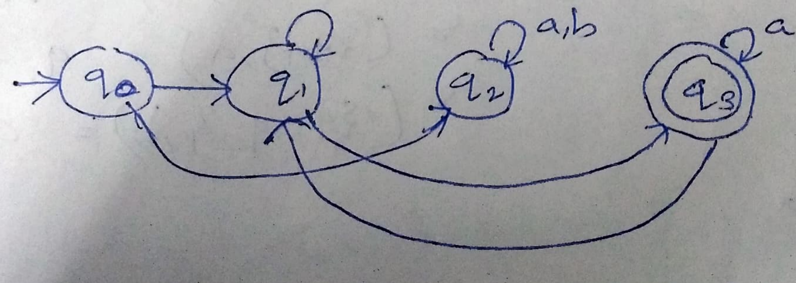
$\delta(q_0, a) = \{q_0, q_1\}$

$\delta(\{q_0, q_1\}, b) = \{q_0, q_2\}$

$\delta(\{q_0, q_2\}, a) = \{q_0, q_1, q_3\}$

$\therefore$ satified.

(2) $L = \{ba, baa, bba, \ldots\}$



δ	a	b
q_0	q_2	q_1
q_1	q_3	q_1
q_2	q_2	q_2
q_3	q_3	q_1

(i) bbabab

$\delta(q_0, b) = q_1$

$\delta(q_1, b) = q_1$

$\delta(q_1, a) = q_3$

$\delta(q_3, b) = q_1$

$\delta(q_1, a) = q_3$

$\delta(q_3, b) = q_1$

$\therefore$ unsatisfied

(ii) baba

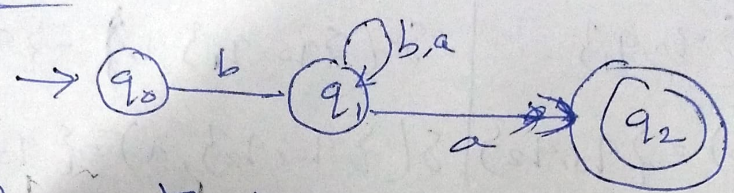
$\delta(q_0, b) = q_1$

$\delta(q_1, a) = q_3$ $\Rightarrow$ $\therefore$ satisfied.

$\delta(q_3, b) = q_1$

$\delta(q_1, b) = q_3$

NFA :



δ	a	b
q_0	ϕ	$\{q_1\}$
q_1	$\{q_1, q_2\}$	$\{q_1\}$
q_2	ϕ	ϕ

(i) bbabab

$\delta(q_0, b) = q_1$

$\delta(q_1, b) = q_1$

$\delta(q_1, a) = \{q_1, q_2\}$

$\delta(\{q_1, q_2\}, b) = q_1$

$\delta(\{q_1, q_2\}, b) = q_1$

$\delta(\{q_1\}, a) = q_1, q_2$

$\delta(\{q_1, q_2\}, b) = q_1$

(ii) baba

$\delta(q_0, b) = q_1$

$\delta(q_0, a) = \{q_1, q_2\}$

$\delta(\{q_1, q_2\}, b) = q_1$

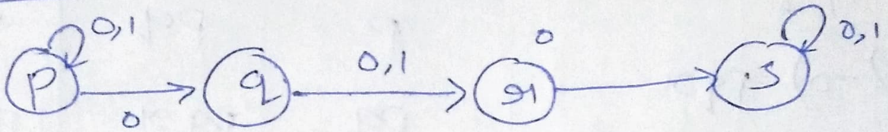
$\delta(\{q_1\}, a) = \{q_1, q_2\}$

$\therefore$ satisfied.

(3) $M = \{Q, \Sigma, F, S\}$ | $\Sigma = \{0,1\}$

$Q = \{P, Q, r, s\}$ | $F = \{q\}$

NFA



$\delta(P,0) = \{p,q\}$

$\delta(P,) = \{P\}$

$\delta(\{p,q\},0) = \{p,q,r\}$

$\delta(\{p,q\},1) = \{p,r\}$

$\delta(\{p,q,r\},0) = \{p,r,s\}$

$\delta(\{p,q,r\},0) = \{p,r,s\}$

$\delta(\{p,q,r\},1) = \{p,r\}$

$\delta(\{p,r\},0) = \{p,r,s\}$

$\delta(\{p,r\},1) = P$

$\delta(\{p,q,r,s\},0) = \{p,q,r,s\}$

DFA:

$q' =$

DFA

$M' = \{Q', \Sigma, P, F, S\}$

$\delta(P,0) = pq$

$\delta(pq,0{=}0) = pqr$

~~$\delta(pq,1)$~~

$\delta(P,1) = P$

$\delta(pq,1) = pr$

$\delta(pqr,0) = prs$

$\delta(pqr,1) = pr$

$\delta(pr,0) = pqs$

$\delta(pqrs,1) = prs$

$\delta(pqs,1) = prs$

$\delta(pqs,1) = prs$

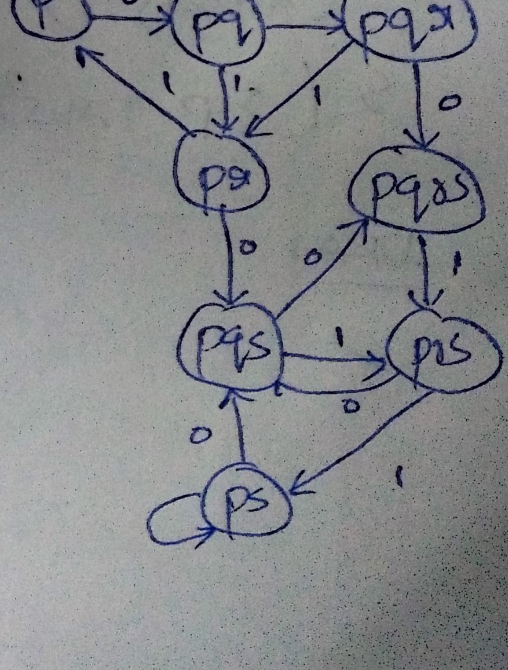
$\delta(prs,1) = ps$

$\delta(ps,0) = pqs$

$\delta(ps) = ps$

Transition table

δ	0	1
p	pq	p
pq	pqr	pr
pqr	pqrs	pr
pr	pq	p
pqrs	pqrs	prs
pqs	pqrs	prs
prs	pqs	ps
ps	pqs	ps



$Q' = \{p, pq, pqr, pr, pqrs, pqs, prs, ps\}$

$F = \{pqrs, pqs, prs, ps\}$, $\Sigma = \{0, 1\}$

(ii) $M = \{Q, \Sigma, P, F, S\}$, $F = \{q, s\}$

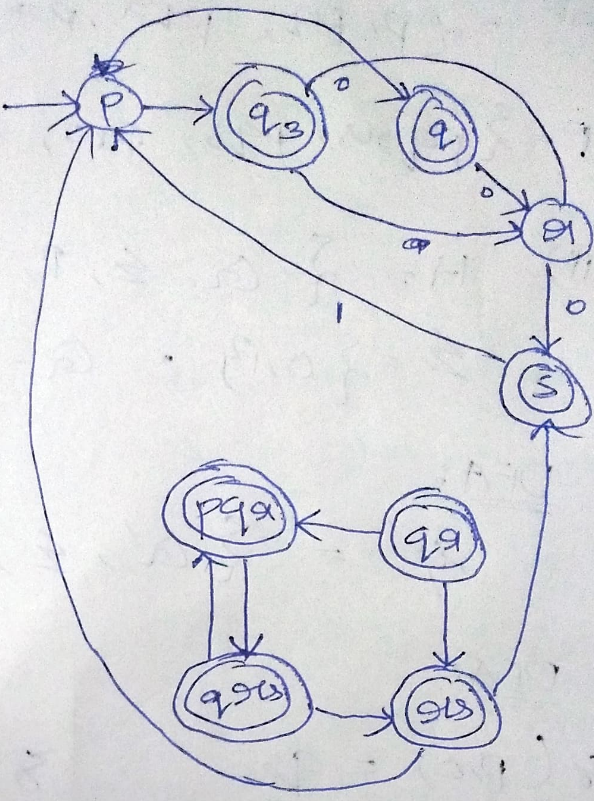
$\Sigma = \{0, 1\}$, $Q = \{p, q, r, s\}$

<u>DFA:</u>

$M' = \{Q', \Sigma, S, F', S'\}$

<u>DFA:</u>	<u>NFA:</u>
$\delta(p, 0) = qs$	$\delta(p, 0) = \{q, s\}$
$\delta(p, 1) = q$	$\delta(p, 1) = a$
$\delta(qs, 0) = r$	$\delta(\{q, s\}, 0) = r$
$\delta(qs, 1) = pqr$	$\delta(\{q, s\}, 1) = \{p, q, r\}$
$\delta(q, 0) = r$	$\delta(\{q\}, 0) = r$
$\delta(r, 0) = s$	$\delta(q, 1) = \{q, r\}$
$\delta(r, 1) = p$	$\delta(r, 0) = s$
$\delta(pqr, 0) = qrs$	$\delta(r, 1) = p$
$\delta(pqr, 1) = pqr$	$\delta(\{p, q, r\}, 0) = \{q, r, s\}$
$\delta(pqr, 0) = rs$	$\delta(\{q, r\}, 0) = \{r, s\}$
$\delta(qr, 1) = pqr$	$\delta(\{q, r\}, 1) = \{p, q, r\}$
$\delta(s, 0) = \phi$	$\delta(s, 0) = \phi$
$\delta(s, 1) = p$	$\delta(s, 1) = p$
$\delta(qrs, 0) = rs$	$\delta(\{q, r, s\}, 0) = \{r, s\}$
$\delta(qrs, 1) = rs$	$\delta(\{q, r, s\}, 1) = \{p, q, r\}$
$\delta(rs, 0) = s$	$\delta(\{r, s\}, 0) = s$
$\delta(rs, 1) = p$	$\delta(\{r, s\}, 1) = p$

S	0	1
p	qr	q
qs	r	pq
q	r	qr
r	s	p
pqr	qrs	pqr
qr	rs	pqr
s	–	p
qrs	rs	p
rs	s	pqr
		p



(iii) $M = (Q, \Sigma, q_0, F, \delta)$, $\Sigma = \{0, 1\}$

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

<u>DFA:</u>

$\delta(q_0, 0) = q_0q_1$

$\delta(q_0, 1) = q_1$

$\delta(q_0q_1, 0) = q_0q_1$

$\delta(q_0q_1, 1) = q_0q_1$

$\delta(q_0, q_1, 1) = q_0q_1$

$\delta(q_1, 0) = q_0$

$\delta(q_1, 1) = q_0q_1$

<u>NFA:</u>

$\delta(q_0, 0) = \{q_0, q_1\}$

$\delta(q_0, 1) = q_1$

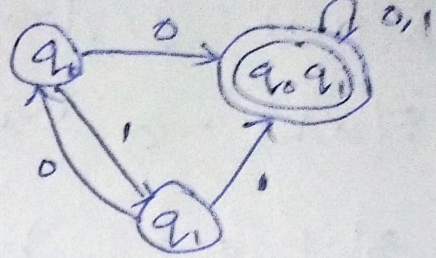
$\delta(\{q_0, q_1\}, 0) = \{q_0, q_1\}$

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

$\delta(\{q_1, 0\}) = q_0$

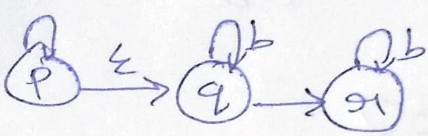
$\delta(q_1, 1) = \{q_0, q_1\}$

δ'	0	1
q_0	q_0q_1	q_1
q_0q_1	q_0q_1	q_0q_1
q_1	q_0	q_0q_1



④ (i)

<u>ε - NFA</u>



ε- closure $(p) = \{p, q, r\}$

ε - closure $(q) = \{q, r\}$

ε - closure $(r) = \{r\}$.

$F = F \cup \{p\} = \{p, r\}$.

$\delta(p, a) = \varepsilon\text{-closure}(\delta(\delta(p, \varepsilon)), a)$

$\varepsilon\text{-closure}(p) = \{p, q, r\}$.

$\delta(p, b) = \varepsilon\text{-closure}(\delta(r(p, \varepsilon)), b))$

$= \varepsilon\text{-closure}(q, r) = \{q, r\}$.

$\delta(q, a) = \varepsilon\text{-closure}(\delta(\delta(q, \varepsilon)), a)$

$= \varepsilon\text{-closure}(\delta(q, r), b) = \phi$

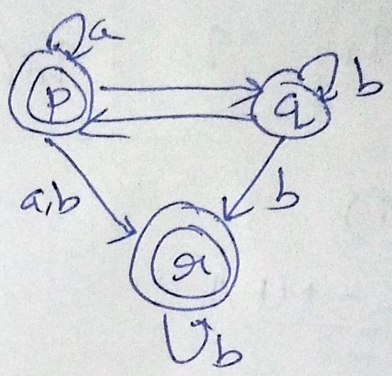
$\delta(q, b) = \varepsilon\text{-closure}(\delta(\delta(q, \varepsilon), b)$

$= \{q, r\}$

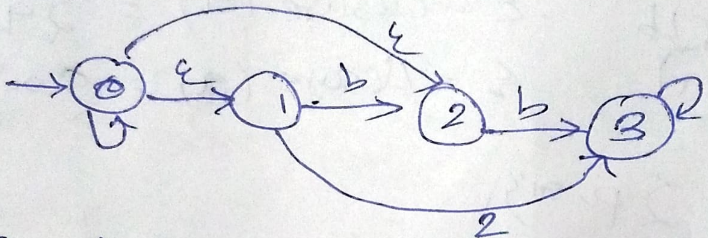
$\delta(r, a) = \varepsilon\text{-closure}(\delta(\delta(r, \varepsilon), a)) = \phi$

$\delta(r, b) = \varepsilon\text{-closure}(\delta(\delta(r, \varepsilon), b)) = \{r\}$

δ'	a	b
p	$\{p, q, r\}$	$\{q, r\}$
q	ϕ	$\{q, r\}$
r	ϕ	$\{r\}$



(ii)



ε - closure of 0 = 0, 1, 2, 3
ε - closure of 1 = 1, 3
ε - closure of 2 = 2
ε - closure of 3 = 3

$\delta(0, a) = \varepsilon\text{-closure}(\delta(\delta(0, \varepsilon), a)) = \{0, 1, 2, 3\}$

$\delta(0, b) = \varepsilon\text{-closure}(\delta(\delta(0, \varepsilon), b)) = \{2, 3\}$

$\delta(1, a) = \varepsilon\text{-closure}(\delta(\delta(1, \varepsilon), a)) = \phi$

$\delta(1, b) = \varepsilon\text{-closure}(\delta(\delta(1, \varepsilon), b)) = \{2\}$

$\delta(2, a) = \varepsilon\text{-closure}(\delta(\delta(2, \varepsilon), b)) = \{3\}$

$\delta(0, c) = \{3\}$, $\delta(1, c) = \{3\}$, $\delta(2, c) = \phi$

$\delta(3, c) = \{3\}$