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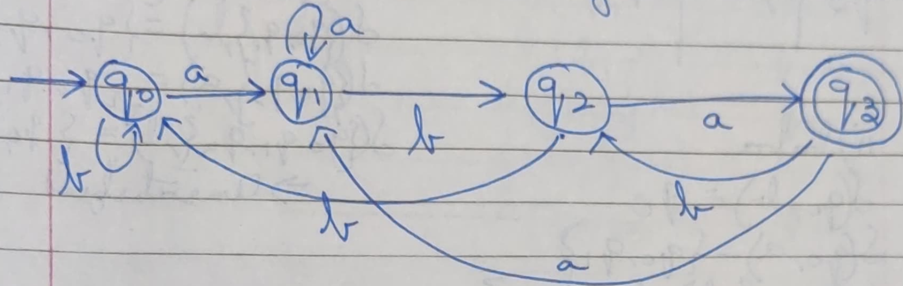
UCS1503 - Theory of Computation
Assignment - 1

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_1	q_2

Checking for

i) bbabab

$\delta(q_0, b) = q_0$

$\delta(q_0, b) = q_0$

$\delta(q_0, a) = q_1$

$\delta(q_1, b) = q_2$

$\delta(q_2, a) = q_3$

$\delta(q_3, b) = q_2$

$\Rightarrow$ Not satisfied

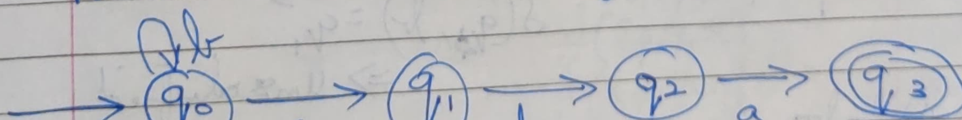
ii) baba

$\delta(q_0, b) = q_0$ $\quad \delta(q_0, a) = q_1$ $\quad \delta(q_1, b) = q_2$

$\delta(q_2, a) = q_3$

$\Rightarrow$ Satisfied

NFA Transition diagram.



Transition Table

δ	a	b
q_0	$\{q_0, q_1\}$	q_0
q_1	ϕ	q_2
q_2	q_3	ϕ
q_3	ϕ	ϕ

ii) baba

$\delta(q_0, b) = q_0$

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

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

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

Checking word

i) bbabab

$\delta(q_0, b) = q_0$

~~$\Rightarrow$ Unsatisfied~~

$\delta(q_0, b) = q_0$

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

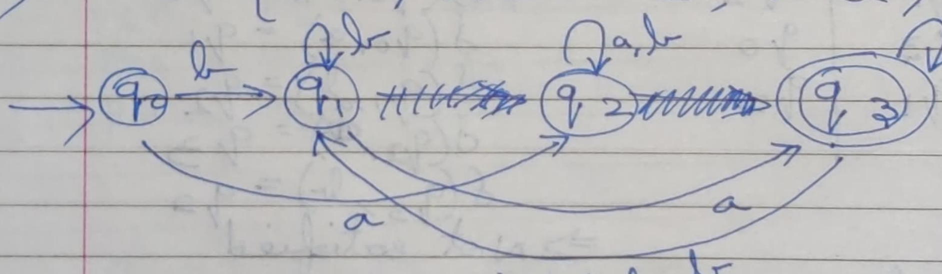
$\delta(\{q_0, q_1\}, b) = \{q_0, q_2\}$

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

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

$\Rightarrow$ Unsatisfied

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



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

$\delta(q_0, b) = q_1$

$\delta(q_1, b) = q_1$

$\delta(q_1, a) = q_3$

$\delta(q_3, b) = q_1$

$\delta(q_1, a) = q_3$

$\delta(q_3, b) = q_1$

$\Rightarrow$ Unsatisfied

ii) baba

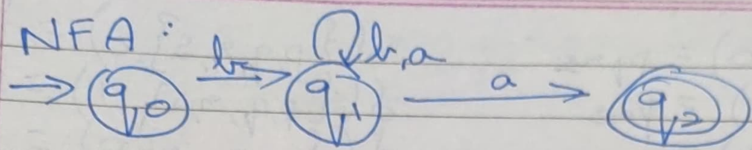
$\delta(q_0, b) = q_1$

$\delta(q_1, b) = q_3$

$\delta(q_1, a) = q_3$

$\delta(q_3, b) = q_1$

NFA :



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

i) bbabab

$\delta(q_0, b) = q_1$

$\delta(q_1, b) = q_1$

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

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

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

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

ii) baba

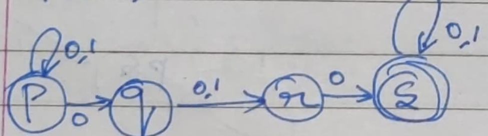
$\delta(q_0, b) = q_1$

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

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

$\delta(\{q_1\}, a\}$ $\{q_1, q_2\}$ => Satisfied

2) NFA



$M = \{Q, \Sigma, P, F, \delta\}$

$Q = \{P, Q, r, s\}$

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

DFA :

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

$\delta(p, 0) = pq$

$\delta(p, 1) = p$

$\delta(pq, 0) = pqr$

$\delta(pq, 1) = pr$

$\delta(pqr, 0) = pqrs$

$\delta(pqr, 1) = pr$

$\delta(pr, 0) = pqs$

$\delta(pr, 1) = p$

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

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

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

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

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

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

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

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

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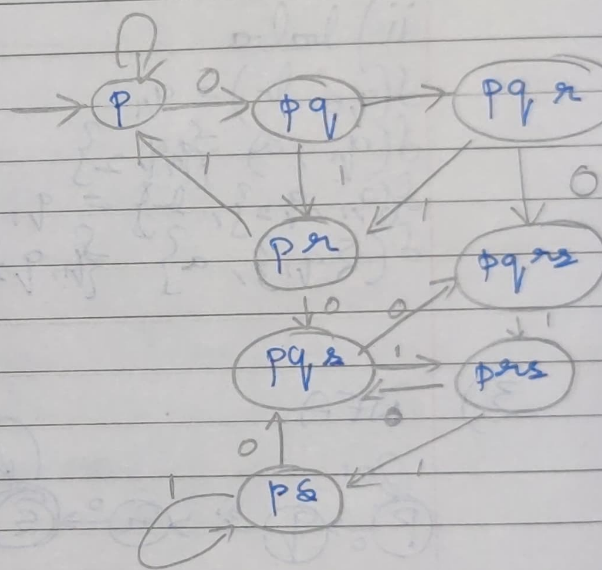
$\delta(pqrs, 0) = pqrs$
$\delta(pqrs, 1) = prs$
$\delta(pqs, 0) = pqrs$
$\delta(pqs, 1) = prs$
$\delta(prs, 0) = pqs$
$\delta(prs, 1) = ps$
$\delta(ps, 0) = pqs$
$\delta(ps, 1) = ps$

$\delta(\{p,q,r,s\}, 0) = \{p,q,r,s\}$
$\delta(\{p,q,r,s\}, 1) = \{p,r,s\}$
$\delta(\{p,q,s\}, 0) = \{p,q,r,s\}$
$\delta(\{p,q,s\}, 1) = \{p,r,s\}$
$\delta(\{p,r,s\}, 0) = \{p,q,s\}$
$\delta(\{p,r,s\}, 1) = \{p,s\}$
$\delta(\{p,s\}, 0) = \{p,q,s\}$
$\delta(\{p,s\}, 1) = \{p,s\}$

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



$Q' = \{p, pq, pqr, pr, pqrs, pqs, prs, ps\}$
$\Sigma = \{0, 1\}$ $F = \{pqrs, pqs, prs, ps\}$

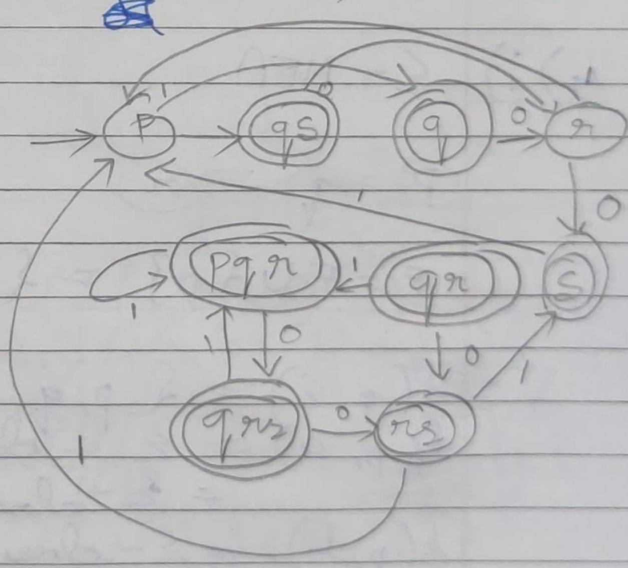
ii) $M = \{Q, \Sigma, p, F, \delta\}$ $Q = \{p, q, r, s\}$
$F = \{q, s\}$ $\Sigma = \{0, 1\}$

DFA :
$M' = \{Q', \Sigma, q, F', \delta'\}$

$\delta(p,0) = qs$
$\delta(p,1) = q$
$\delta(qs,0) = r$
$\delta(qs,1) = pqr$
$\delta(q,0) = r$
$\delta(q,1) = qr$
$\delta(r,0) = s$
$\delta(r,1) = p$
$\delta(pqr,0) = qrs$
$\delta(pqr,1) = pqr$
$\delta(qr,0) = rs$
$\delta(qr,1) = pqr$
$\delta(s,0) = \phi$
$\delta(s,1) = p$
$\delta(qrs,0) = rs$
$\delta(qrs,1) = pqr$
$\delta(rs,0) = s$
$\delta(rs,1) = p$

$\delta(p,0) = \{q,s\}$
$\delta(p,1) = q$
$\delta(\{q,s\},0) = r$
$\delta(\{q,s\},1) = \{p,q,r\}$
$\delta(\{q\},0) = r$
$\delta(q,1) = \{q,r\}$
$\delta(r,0) = s$
$\delta(r,1) = p$
$\delta(\{p,q,r\},0) = \{q,r,s\}$
$\delta(\{p,q,r\},1) = \{p,q,r\}$
$\delta(\{q,r\},0) = \{r,s\}$
$\delta(\{q,r\},1) = \{p,q,r\}$
$\delta(s,0) = \phi$
$\delta(s,1) = p$
$\delta(\{q,r,s\},0) = \{r,s\}$
$\delta(\{q,r,s\},1) = \{p,q,r\}$
$\delta(\{r,s\},0) = s$
$\delta(\{r,s\},1) = p$

δ'	0	1
p	qs	q
qs	r	pqr
q	r	qr
r	s	p
pqr	qrs	pqr
qr	rs	pqr
s	–	p
qrs	rs	pqr
rs	s	p

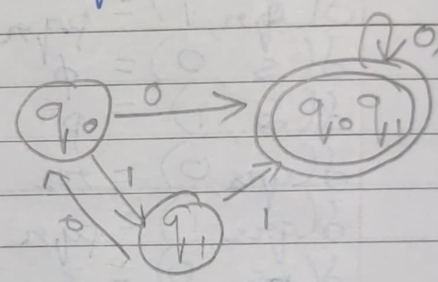


iii) $M = (Q, \Sigma, q_0, F, \delta)$
$Q = \{q_0, q_1\}$
$\Sigma = \{0, 1\}$
$F = \{q_0\}$

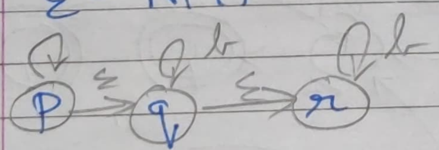
$\delta(q_0, 0) = q_0 q_1$
$\delta(q_0, 1) = q_1$
$\delta(q_0 q_1, 0) = q_0 q_1$
$\delta(q_0 q_1, 1) = q_0 q_1$
$\delta(q_1, 0) = q_0$
$\delta(q_1, 1) = q_0 q_1$

$\delta(q_0, 0) = \{q_0, q_1\}$
$\delta(q_0, 1) = q_1$
$\delta(\{q_0, q_1\}, 0) = \{q_0, q_1\}$
$\delta(\{q_0, q_1\}, 1) = \{q_0, q_1\}$
$\delta(q_1, 0) = q_0$
$\delta\{q_1, 1) = \{q_0, q_1\}$

δ'	0	1
q_0	$q_0 q_1$	q_1
$q_0 q_1$	$q_0 q_1$	$q_0 q_1$
q_1	q_0	$q_0 q_1$



4) i) ε - NFA

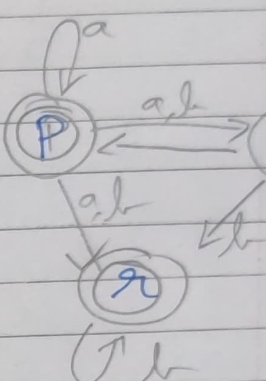


ε-closure $(p) = \{p, q, r\}$
ε-closure $(q) = \{q, r\}$
ε-closure $r = \{r\}$

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

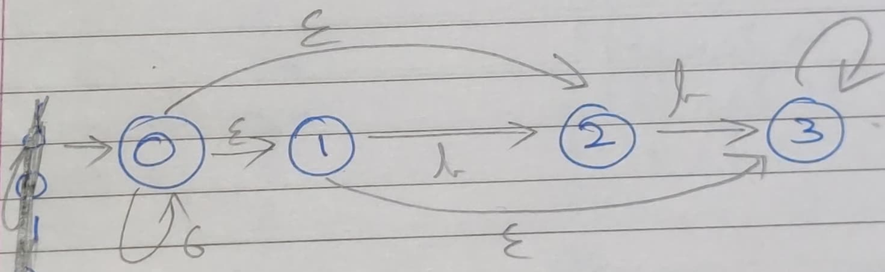
$\delta(p, \varepsilon) = \{p, q, r\}$
$\delta(p, a) = \varepsilon$-closure $(\delta(\delta\, p, \varepsilon)), a)$
$= \varepsilon$-closure $(p) = \{p, q, r\}$
$\delta(p, b) = \varepsilon$-closure $(\delta(\delta(p, \varepsilon), b))$
$= \varepsilon$-closure $(q, r) = \{q, r\}$
$\delta(q, a) = \varepsilon$-closure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

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



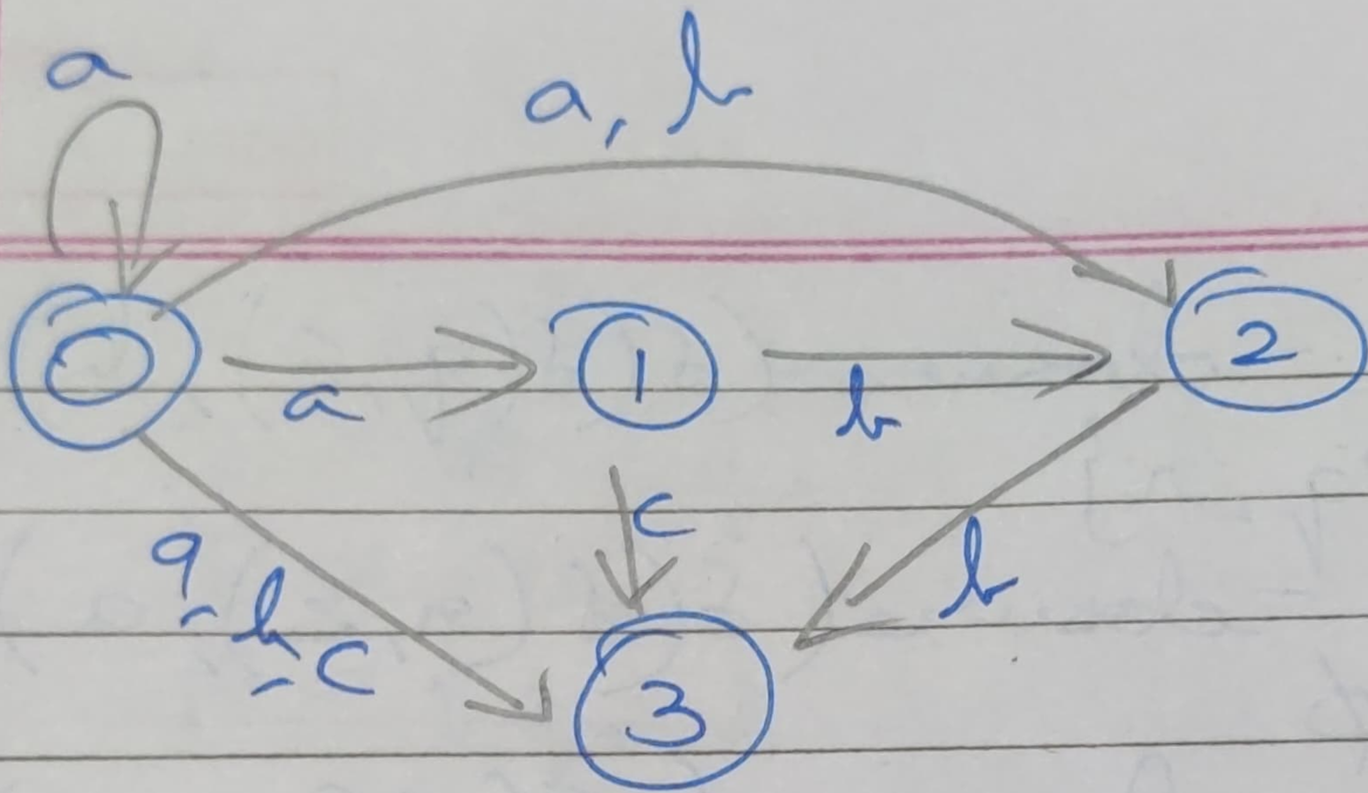
δ'	a	b
*p	$\{p,q,r\}$	$\{q,r\}$
q	ϕ	$\{q,r\}$
*r	ϕ	$\{r\}$

ii)



ε closure of 0 = 0, 1, 2, 3
1 = 1, 3
2 = ~~φ~~ 2
3 = 3

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



a
a, b
0
a
1
b
2
c
a, b, c
b
3