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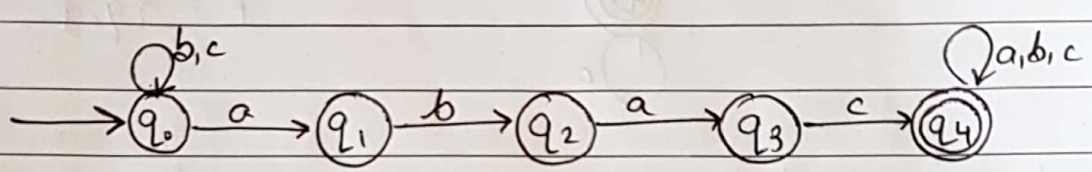
T.C.S Tutorial 2

Q1.) Determine an NFA accepting the language

a) $L1 = \{x \mid x \in \{a,b,c\}^* \text{ and } x \text{ contains the pattern abac}\}$

Soln:-



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

$Q = \{q_0, q_1, q_2, q_3, q_4\}$

$F = \{q_4\}$

$q_0 = \{q_0\}$; δ = as per TD.

$\Sigma = \{a, b, c\}$

b) $L2 = \{a^* \cup b^*\}$

Soln:- $M = (Q, \Sigma, \delta, q_0, F)$

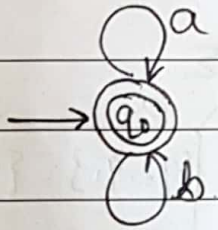
$Q = \{q_0\}$

$F = \{q_0\}$

$\Sigma = \{a, b\}$

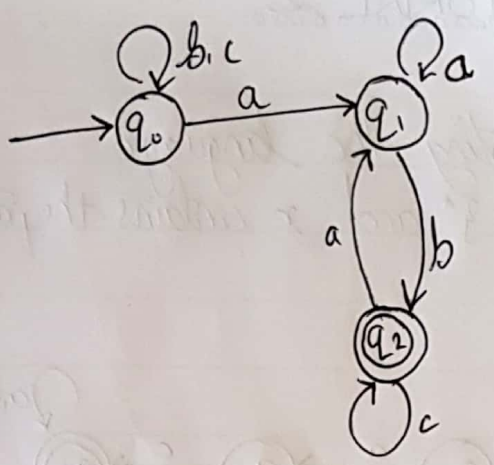
$q_0 = \{q_0\}$

δ = as per TD.



Q2.) Determine NFA with three states that accepts languages $\{ab, abc\}^*$

Soln:- $M = (Q, \Sigma, \delta, q_0, F)$



$Q = \{q_0, q_1, q_2\}$
$\Sigma = \{a, b, c\}$
δ = as per TD
$q_0 = \{q_0\}$
$F = \{q_0\}$

Q3.) Find the equivalent DFA from given NFA whose transition function is as follows :

	a	b
q_0	$\{q_0, q_1\}$	-
q_1	-	$\{q_1, q_2\}$
* q_2	-	-

Soln:-

$M = (Q, \Sigma, \delta, q_0, F)$
$Q = \{q_0, q_1, q_2, q_3\}$
$F = \{q_2\}$; $q_0 = \{q_0\}$
$\Sigma = \{a, b\}$

Q \ Σ	a	b
q_0	$\{q_0, q_1\}$	$\{q_3\}$
q_1	$\{q_3\}$	$\{q_1, q_2\}$
q_2	$\{q_3\}$	$\{q_3\}$
(dead) q_3	$\{q_3\}$	$\{q_3\}$

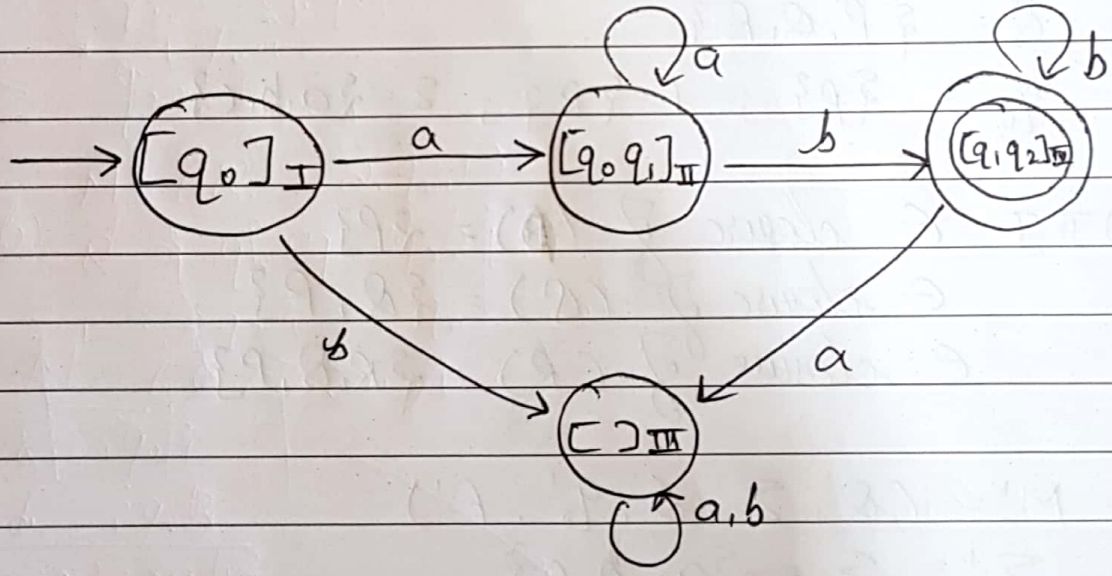
- Equivalent DFA —

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

$\Sigma' = \Sigma = \{a, b\}$

$q_0' = [q_0]_I$

Q' \ Σ'	a	b
$[q_0]_I$	$[q_0 q_1]_{II}$	$[\,]_{IV}$
$[q_0 q_1]_{II}$	$[q_0 q_1]_{II}$	$[q_1 q_2]_{IV}$
$[q_1 q_2]_{III}$	$[\,]_{III}$	$[q_1 q_2]_{IV}$
$[\text{lead}]_{III}$	$[\,]_{III}$	$[\,]_{III}$



$Q' = \{ \text{I}, \text{II}, \text{III}, \text{IV} \}$

δ' = as per TD/TT

$F' = \{ \text{IV} \}$

Q4.) Consider the following ε-NFA

Soln:-

	ε	a	b	c
→ P		{P}	{Q}	{R}
Q	{P}	{Q}	{R}	-
*R	{Q}	{R}		{P}

a.) Compute the ε-closure of each state

b.) Give all the strings of length three or less accepted by the automation

c.) Convert the automation to DFA.

Soln:- c.) I.] $M = (Q, \Sigma, \delta, q_0, F)$

$Q = \{P, Q, R\}$

$q_0 = \{P\}$; $F = \{R\}$; $\Sigma = \{a, b, c\}$

a.) II.] ∈ closure of (P) = {P}

∈ closure of (Q) = {Q, P}

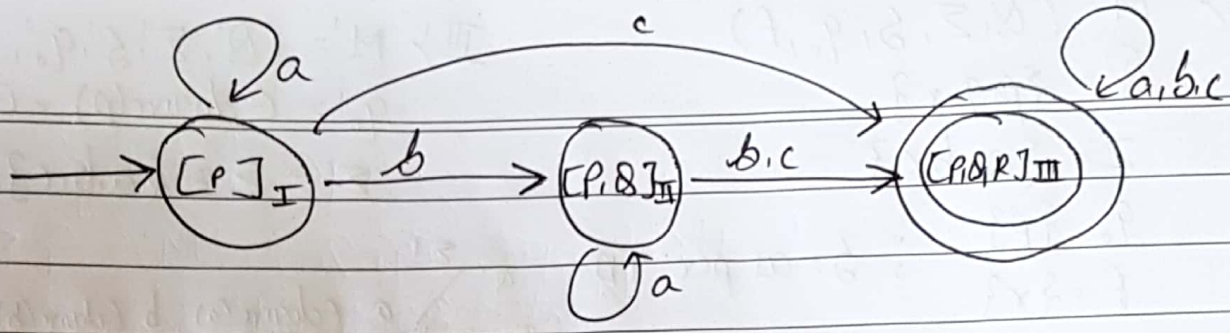
∈ closure of (R) = {R, Q, P}

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

$\Sigma' = \Sigma = \{a, b, c\}$

q_0' = ∈ closure of (P) = $\{[P]_I\}$

Q' \ Σ'	a	∈closure(a)	b	∈closure(b)	c	∈closure(c)
$[P]_I$	$[P]_I$	$[P]_I$	{Q}	$[P,Q]_{II}$	{R}	$[P,Q,R]_{III}$
$[P,Q]_{II}$	{P,Q}	$[P,Q]_{II}$	{Q,R}	$[P,Q,R]_{III}$	{R}	$[P,Q,R]_{III}$
$[P,Q,R]_{III}$	{P,Q,R}	$[P,Q,R]_{III}$	{Q,R}	$[P,Q,R]_{III}$	{P,R}	$[P,Q,R]_{III}$



δ' = { I, II, III }

F' = { III } ; δ' = as per T-Diagram

b.) Strings = { c, bb, bab, ccc, ac, aac, ca, caa, bba }

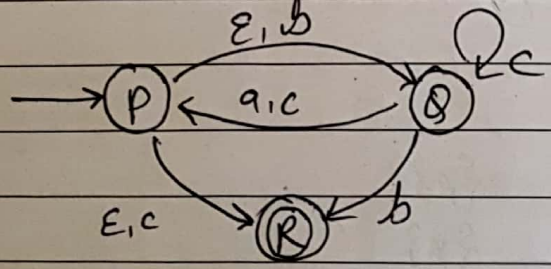
Q5.) Repeat the above exercise for the following NFA

	ε	a	b	c
→ p	{q, r}	-	{q}	{r}
q	-	{p}	{r}	{p, q}
*r	-	-	-	-

Soln:- ∈ closure of (P) = {p, q, r}

II) ∈ closure of (Q) = {q}

∈ closure of (R) = {r}



Strings = { c, bb, bcc, bcb }

I) $M = (Q, \Sigma, \delta, q_0, f)$

$Q = \{p, q, r\}$

$\Sigma = \{a, b, c\}$

$q_0 = \{p\}$

$f = \{r\}$

; δ = as per T.D.

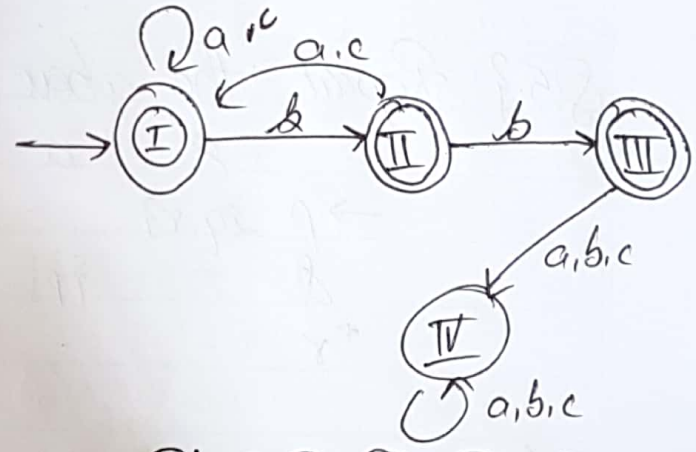
Q \ Σ	ε	a	b	c
p	{q,r}	-	{q}	{r}
q	-	{p}	{r}	{p,q}
r	-	-	-	-

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

$q_0' = \in\text{closure}(p) = [p,q,r]_I$

$\Sigma' = \Sigma = \{a, b, c\}$

Q' \ Σ'	a ∈closure(a)	b ∈closure(b)	c ∈closure(c)
$[p,q,r]_I$	{p}	$[p,q,r]_I$ {q,r}	$[q,r]_{II}$ {p,q,r} $[p,q,r]_I$
$[q,r]_{II}$	{p}	$[p,q,r]_I$ {r}	$[r]_{III}$ {p,q} $[p,q,r]_I$
$[r]_{III}$	{ }	$[\,]_{IV}$	{ } $[\,]_{IV}$ { } $[\,]_{IV}$
$[\,]_{IV}$	{ }	$[\,]_{IV}$	{ } $[\,]_{IV}$ { } $[\,]_{IV}$



δ' = as per T.D. ; $Q' = \{I, II, III, IV\}$

$f' = \{III, II, I\}$

Q6) Convert to DFA the following NFA

	0	1
→p	{p,q}	{p}
q	{r}	{r}
r	{s}	-
*s	{s}	{s}

Soln:- I.)

δ	0	1
p	{p,q}	{p}
q	{r}	{r}
r	{s}	-
s	{s}	{s}

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

$Q = \{p, q, r, s\}$

$q_0 = \{p\}$; $F = \{s\}$

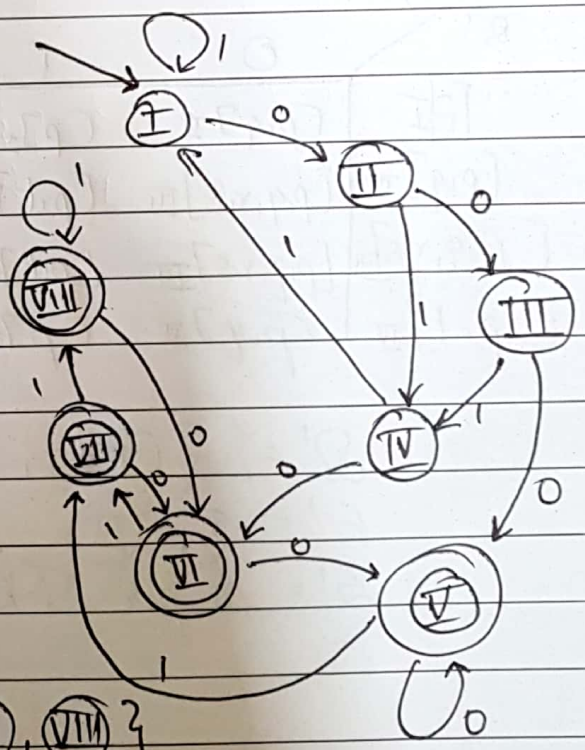
II.] $M' = (Q', \Sigma', \delta', q_0', F')$

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

$Q' = ?$

$q_0' = \{[q_0]_I\} = \{[p]_I\}$

Q'	0	1
$[p]_I$	$[p,q]_{II}$	$[p]_I$
$[p,q]_{II}$	$[p,q,r]_{III}$	$[p,r]_{IV}$
$[p,q,r]_{III}$	$[p,q,r,s]_I$	$[p,r]_{IV}$
$[p,r]_{IV}$	$[p,q,s]_{VI}$	$[p]_I$
$[p,q,r,s]_V$	$[p,q,r,s]_I$	$[p,r,s]_{VII}$
$[p,q,s]_{VI}$	$[p,q,r]_V$	$[p,r,s]_{VII}$
$[p,r,s]_{VII}$	$[p,q,s]_{VI}$	$[p,s]_{VIII}$
$[p,s]_{VIII}$	$[p,q,s]_{VI}$	$[p,s]_{VIII}$



$Q' = \{(I), (II), (III), (IV), (V), (VI), (VII), (VIII)\}$

$F' = \{(V), (VI), (VII), (VIII)\}$; δ' = as per T.D

* Advanced Section

Q1.] Find the equivalent DFA from given NFA

		0	1
→	p	{p, q}	{p}
	q	{r, s}	{t}
	r	{p, r}	{t}
*	s		
*	t		

Sol:- $M = (Q, \Sigma, \delta, q_0, F)$

$Q = \{p, q, r, s, t\}$; $F = \{s, t\}$

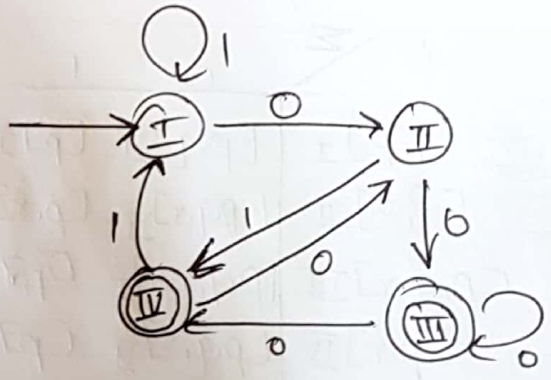
$\Sigma = \{0, 1\}$; $q_0 = \{p\}$

in DFA

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

$q_0' = \{[p]_I\}$; $\Sigma' = \Sigma = \{0, 1\}$

Q' \ Σ'	0	1
$[p]_I$	$[p,q]_{II}$	$[p]_I$
$[p,q]_{II}$	$[p,q,r,s]_{III}$	$[p,t]_{IV}$
$[p,q,r,s]_{III}$	$[p,q,r,s]_{III}$	$[p,t]_{IV}$
$[p,t]_{IV}$	$[p,q]_{II}$	$[p]_I$

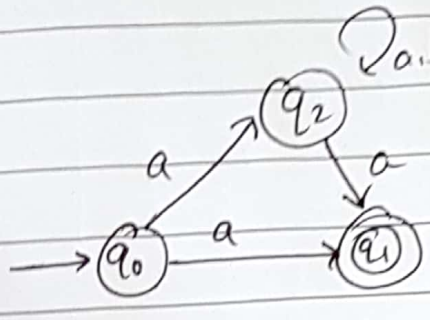


$Q' = \{[p]_I, [p,q]_{II}, [p,q,r,s]_{III}, [p,t]_{IV}\}$

$F' = \{$ (III) , (IV) $\}$

δ' = as per T.D

Q2.] Find the equivalent DFA for given NFA



Soln:- $M = (Q, \Sigma, \delta, q_0, F)$

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

$q_0 = \{q_0\}$

$F = \{q_1\}$; $\Sigma = \{a, b\}$

Q \ Σ	a	b
q_0	$\{q_1, q_2\}$	-
q_1	-	-
q_2	$\{q_1, q_2\}$	$\{q_2\}$

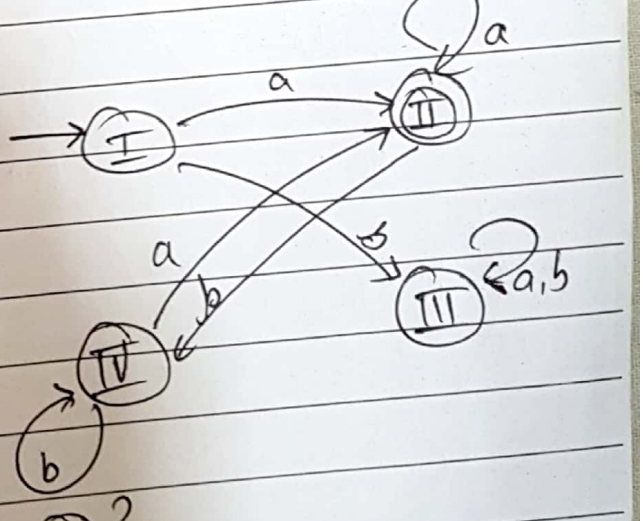
in DFA

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

$\Sigma' = \Sigma = \{a, b\}$

$q_0' = \{[q_0]_I\}$

Q' \ Σ'	a	b
$[q_0]_I$	$[q_1 q_2]_{II}$	$[\,]_{III}$
$[q_1 q_2]_{II}$	$[q_1, q_2]_{II}$	$[q_2]_{IV}$
$[\,]_{III}$	$[\,]_{III}$	$[\,]_{III}$
$[q_2]_{IV}$	$[q_1, q_2]_{II}$	$[q_2]_{IV}$



$Q' = \{(I), (II), (III), (IV)\}$

$F' = \{(II)\}$

δ' = as per TD.