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Internal Assessment Test 1 Solution – September 2019

Sub:	Automata Theory and Computability				Sub Code:	17CS54/15 CS54	Branch:	CSE	
Date:	6/9/19	Duration:	90 min's	Max Marks: 50	Sem/Sec:	V/A,B,C			OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1 (a)	What is Finite Automata? Explain the working principle of FA with a diagram.	[4]	CO1	L1,L2

A finite automata is a mathematical model of an abstract machine which contains a finite set of states & transitions between the states.

A FA is defined by 5-tuples.

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

where Q is a set of finite no. of states

Σ is input alphabet set

δ is transition function

q_0 is start state

F is final states. $F \subseteq Q$

There are 3 types of FA

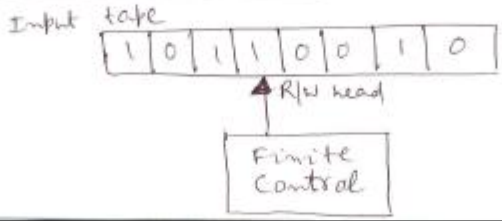
→ DFA

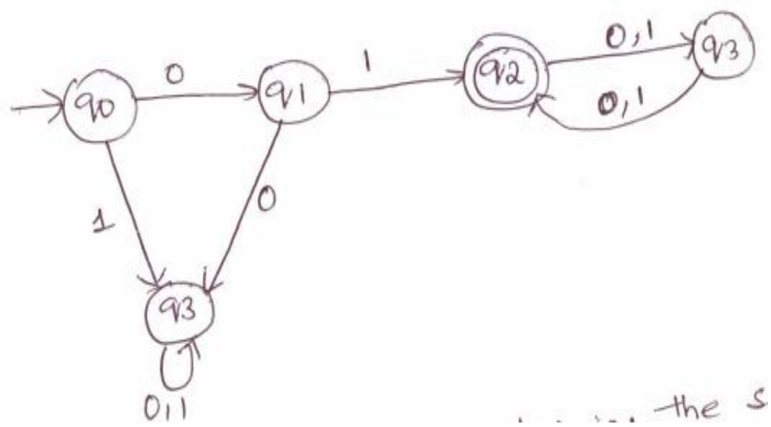
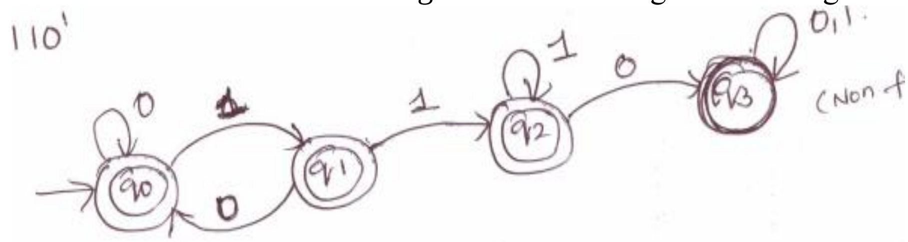
→ NFA

→ ε-NFA

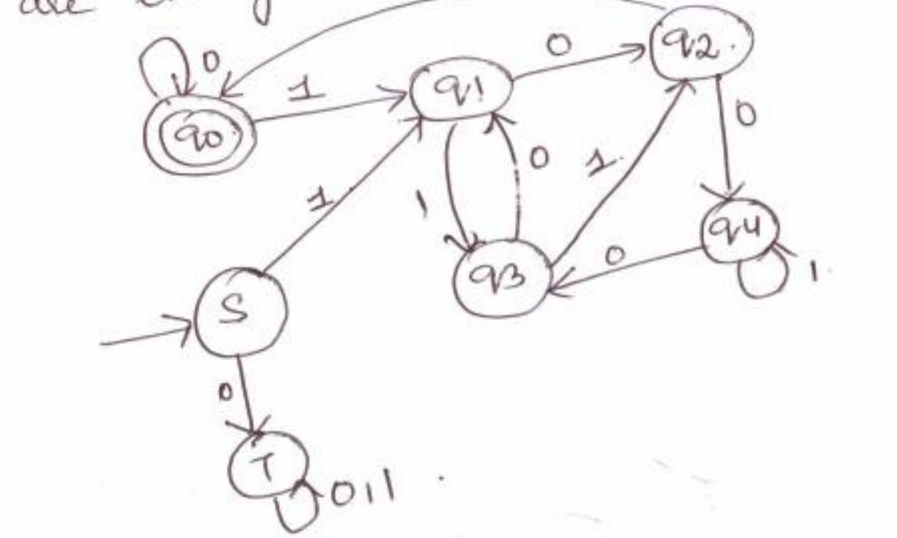
Working Principle of FA

Basic Block diagram



	It contains 3 components. ① Input tape : It is finite in length. It is divided into different cells. Each cell can hold one input at a time. ② R/W Head → It scans the input from left to right. It reads one input at a time & moves the head towards the next right i/p. ③ Finite control → It controls the movement of R/W head.			
(b)	Design a DFA to accept the following languages over $\Sigma = \{0,1\}$ i. L = { w | w is of even length and begins with '01' }  ii. The set of all strings **NOT** containing the substring '110' 	[6]	CO1	L3
2 (a)	Design DFSM for the language L={w Є {0,1}* : w corresponds to the binary encoding, without leading 0's of natural numbers that are evenly divisible by 5}	[5]	CO1	L3

are evenly



(b)	Define the following terms with examples. (i)Alphabet (ii) Concatenation (iii) Languages (iv) Powers of alphabet (v) String	[5]	CO1	L1,L2

Q.1. (a)

(i) Alphabet : An alphabet is a finite non-empty set of symbols. It is denoted by Σ.

Ex $\Sigma = \{0,1\}$ $\Sigma = \{a,b,c\}$

(ii) Concatenation

Given two strings u and v, concatenation of strings u and v, written as u.v, is the sequence obtained by appending u to v.

Ex u = good v = morning

u.v = goodmorning

(iii) Languages

A language over an alphabet Σ is a set of strings over Σ.

$L \subseteq \Sigma^*$

Ex $L = \{a^n b^n \mid n \geq 1\}$

(iv) Powers of alphabet

Given an alphabet Σ, power of Σ, denoted by Σ^m is the set of all strings of length m over Σ.

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

$\Sigma^2 = \{aa, ab, ba, bb\}$

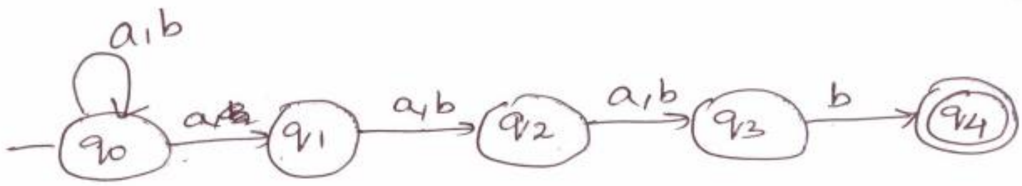
(v) String

A string over Σ is a sequence of symbols from Σ.

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

strings are : ab, abb, baa, ...etc.

3 (a) Construct a NFA for the language L over $\Sigma = \{a, b\}$ which accepts all strings in which the 4th symbol from the right is always ‘a’ and ends with ‘b’. [4] CO1 L3



(b) Convert the following NFA to its equivalent DFA (write the appropriate steps). [6] CO1 L3

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

Sol^n

$\delta(p,0) = \{p,q\} \rightarrow$ (ii) $\quad \delta(p,1) = \{p\}$

$\delta([p,q],0) = \{p,q,r\} \rightarrow$ (iii)

$\delta([p,q],1) = \{p,r\} \rightarrow$ (iv)

$\delta([p,q,r],0) = \{p,q,r,s\} \rightarrow$ (v)

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

$\delta([p,r],0) = \{p,q,s\} \rightarrow$ (vi)

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

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

$\delta([p,q,r,s],1) = \{p,r,s\} \rightarrow$ (vii)

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

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

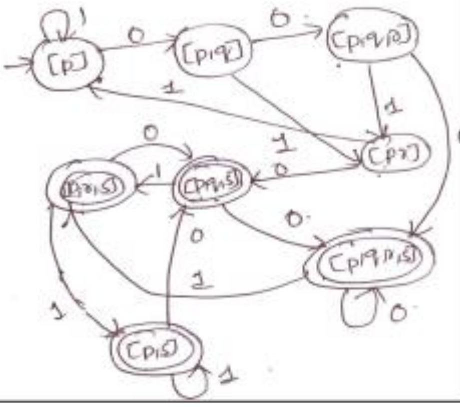
$\delta([p,r,s],0) = \{p,q,s\}$

$\delta([p,r,s],1) = \{p,s\} \rightarrow$ viii)

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

$\delta([p,s],1) = \{p,s\}$.

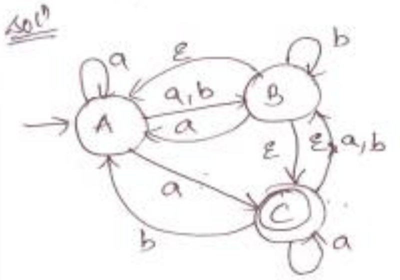
δ	0	1
→ P	{p,q}	{p}
[p,q]	{p,q,r}	{p,r}.
[p,q,r]	{p,q,r,s}	{p,r}
[p,r]	{p,q,s}	{p,r}
* [p,q,r,s]	{p,q,r,s}	{p,r,s}
* [p,q,s]	{p,q,r,s}	{p,r,s}
* [p,r,s]	{p,q,s}	{p,s}
* [p,s]	{p,q,s}	{p,s}



4 (a) Convert the following ε-NFA to DFA. Show the steps for conversion. [6] CO2 L3

	a	b	ϵ
→A	{A,B}	{C}	Ø
B	{A}	{B}	{A,C}
*C	{B,C}	{A,B}	{B}

Sol^{n}



E-close (A) = {A}

E-close (B) = {B, C, A}

E-close (C) = {C, B, A}

	a	b
→ {A}	{A,B,C}	{A,B,C}
* {A,B,C}	{A,B,C}	{A,B,C}

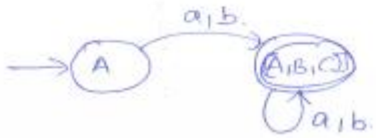
[ii] ~~δ(A,a) = Eclose(δ{A},a) = A~~

~~δ(A,b) = Eclose(δ{A},b)~~

[iii] δ({A},a) = Eclose(δ{A},a)

= Eclose({A,B,C})

= {A,B,C}



δ({A},b) = Eclose(δ{A},b)

= Eclose(C)

= {A,B,C}

δ({A,B,C},a) = Eclose(δ(A,B,C),a)

= Eclose(A,B,C)

= {A,B,C}

δ({A,B,C},b) = Eclose(δ{A,B,C},b)

Eclose(A,B,C}

= {A,B,C}

(b) Write the difference between DFA, NFA and Є-NFA [4] CO2 L1,L2

(b) DFA	NFA	Є-NFA
① There will be exactly one transition from each state on an input.	① There will be zero, one or more transitions from one state to another states on an input.	① There will be ε, one or more transitions from one state to another state on an input.
② $\delta: Q \times \Sigma \rightarrow Q$	② $\delta: Q \times \Sigma \rightarrow 2^Q$	② $\delta: Q \times \Sigma \cup \{\epsilon\} \rightarrow 2^Q$

5 (a) Minimize the following DFA. Draw the minimized DFA. [7] CO2 L3

Input/ State	→A	B	C	*D	E	*F	*G
0	B	D	F	D	F	D	F
1	C	E	G	E	G	E	G

<table>
<tr><td></td><td>

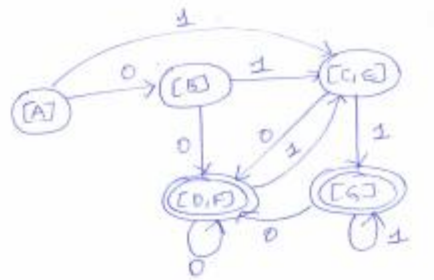
I/P state	0	1
A	B	C
B	D	E
C	F	G
* D	D	E
E	F	G
* F	D	E
* G	F	G

Soln 0 equivalence
[A,B,C,E] [D,F,G]

1 equivalence
[A] [B,C,E] [D,F,G]

2 equivalence
[A] ~~[B,C,E]~~ [B] [C,E] [D,F,G]

3 equivalence
[A] [B] [C,E] [D,F] [G]

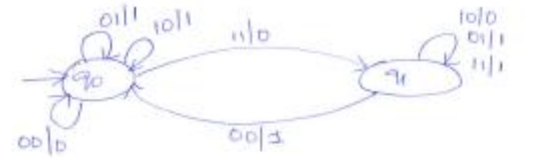
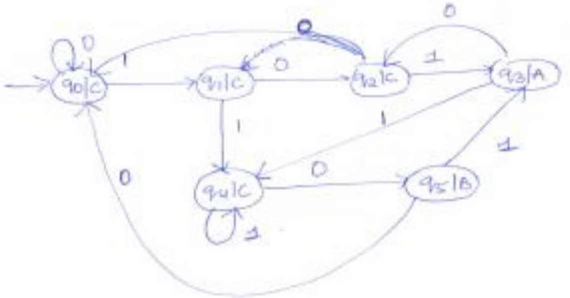


</td><td></td><td></td><td></td></tr>
<tr><td>(b)</td><td>Explain the term 'equivalence state' and 'distinguishable state'.

2.(b) Distinguishable & Indistinguishable state

Two states p & q are distinguishable if there is at least one string w such that one of $\hat{\delta}(p, w)$ and $\hat{\delta}(q, w)$ is accepting & the other is not accepting.

Two states p & q are equivalent or indistinguishable if for all input strings w, $\hat{\delta}(p, w)$ is an accepting state iff $\hat{\delta}(q, w)$ is an accepting state</td><td>[3]</td><td>CO2</td><td>L1,L2</td></tr>
<tr><td>6(a)</td><td>Design a Mealy Machine to find addition of two binary coded natural numbers which will give sum as output. If the input string is 1101 and 1001, show the output string.</td><td>[5]</td><td>CO2</td><td>L3</td></tr>
</table>

	 1101 1001 1] 0110 $q_0 \xrightarrow[0]{11} q_1 \xrightarrow[1]{00} q_0 \xrightarrow[1]{10} q_0 \xrightarrow[0]{11} q_1$ o/p is 0110			
(b)	Design a Moore machine which will give output as **‘A’** on every occurrence of the substring **‘101’**, output as ‘B’ on every occurrence of the substring **‘110’,**otherwise **‘C’**.  	[5]	CO2	L3
7(a)	Prove by induction that “If there exist an Є-NFA which accepts a language L, then there exist an equivalent DFA which accepts same language L” a. Theorem If there exists an Є-NFA which accepts a language L, then there exists an equivalent DFA which accepts same language L. Induction Basis —— 3M $\lvert w \rvert = 0$ so $x = \epsilon$ $\delta_E(q_0, \epsilon) = \{q_0\} = \text{ECLOSE}(q_0)$ $\delta_D(q_0, \epsilon) = \{q_0\}$ Induction hypothesis —— 3M Induction steps —— 4M	[5]	CO2	L2
(b)	Design a DFA to accept the following language over $\Sigma = \{a, b\}$ for L={W| $N_a(W)$ mod 3=2 and $N_b(W)$ mod 4=1}	[5]	CO1	L3

Sol^n

Remaindeey on dividing by 3 = 0,1,2,

Remaindees on dividing by 4 = 0,1,2,3

Cross prod (00,01,02,03,10,11,12,13,20,21,22,23

the states in F.A