Anup Jaiswal
Comp A 58
TCS- FA-1

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Q.1 Design a FA to check whether the given decimal no is divisible by 4

1] $\Sigma = \{0,1,2,3,4,5,6,7,8,9\}$ q_0 = initial state

$\delta : Q \times \Sigma \rightarrow Q$ $Q = \{q_0, q_1, q_2, q_3\}$ $F = \{q_0\}$

2] Consider remainder is state

$q_0 = 0 \rightarrow$ final state

$q_1 = 1 \rightarrow$ Non-final state

$q_2 = 2 \rightarrow$ Non-final state

$q_3 = 3 \rightarrow$ Non-final state

3] Let $A = \{0,4,8\}$, $B = \{1,5,9\}$, $C = \{2,6\}$, $D = \{3,7\}$

Transition Table

Q \ Σ	A	B	C	D
→ q_0^*	q_0	q_1	q_2	q_3
q_1	q_2	q_3	q_0	q_1
q_2	q_0	q_1	q_2	q_3
q_3	q_2	q_3	q_0	q_1

Here * represent final state

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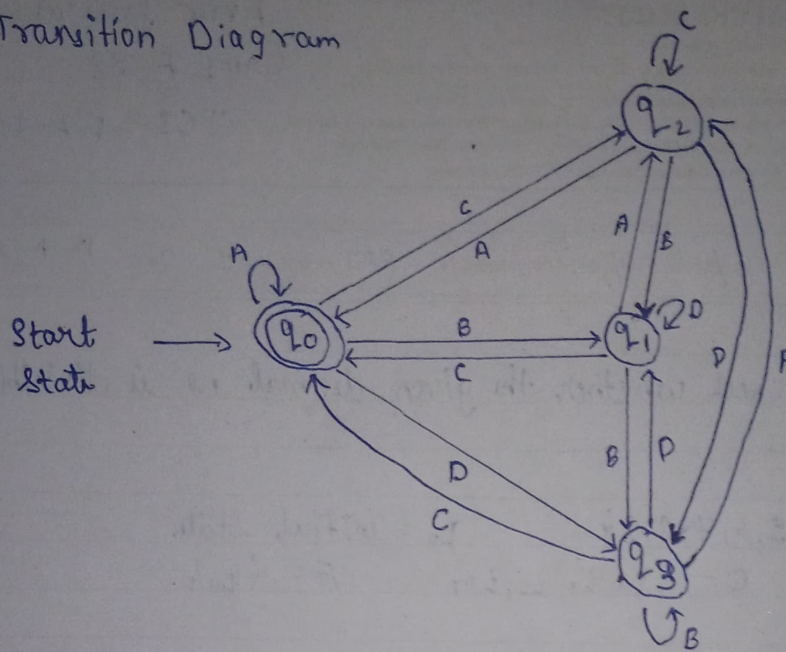
4) Transition Diagram



Example :

$\rightarrow (q_0, 458)$

$\vdash (q_0, 58)$

$\vdash (q_1, 8)$

$\vdash (q_2, \epsilon)$

q_2 is not final state
Hence it is rejected

$\rightarrow (q_0, 216)$

$\vdash (q_2, 16)$

$\vdash (q_1, 6)$

$\vdash (q_0, \epsilon)$

q_0 is final state
Hence it is accepted.

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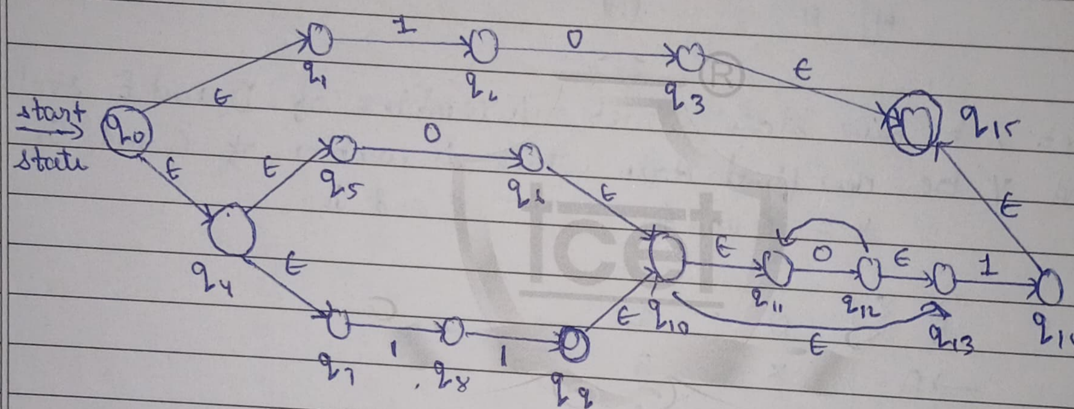
Q.2

(a) Construct a NFA with ε transition the regular expression $10 + (0+11)0^* 1$ and convert into a minimized DFA

→ R.E = $10 + (0+11)0^* 1$

ε-NFA



x	y = ε-closure(x)	δ(y,0)	δ(y,1)
→ $\{q_0\}$ A	$\{q_0, q_1, q_4, q_5, q_7\}$	$\{q_6\}$ D	$\{q_2, q_8\}$ B
$\{q_2, q_8\}$ B	$\{q_2, q_8\}$	$\{q_3\}$ C	$\{q_9\}$ E
$\{q_3\}^*$ C	$\{q_3, q_{15}\}$	ϕ H	ϕ H
$\{q_6\}$ D	$\{q_6, q_{10}, q_{11}\}$	$\{q_{12}\}$ F	ϕ H
$\{q_9\}$ E	$\{q_9, q_{10}, q_{11}\}$	$\{q_{12}\}$ F	ϕ H
$\{q_{12}\}$ F	$\{q_{12}, q_{11}, q_{13}\}$	$\{q_{12}\}$ F	$\{q_{14}\}$ G
$\{q_{14}\}^*$ G	$\{q_{14}, q_{15}\}$	ϕ H	ϕ H
ϕ H	ϕ	ϕ H	ϕ H

let $A = \{q_0\}$ $B = \{q_2, q_8\}$ $C = \{q_3\}$ $D = \{q_6\}$
$E = \{q_9\}$ $F = \{q_{12}\}$ $G = \{q_{14}\}$ $H = \phi$

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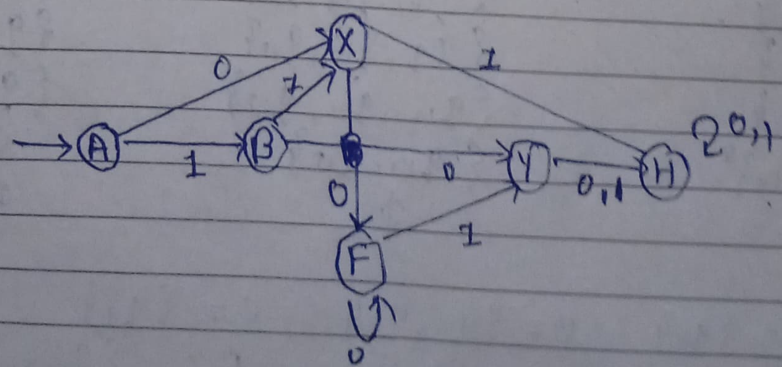
Q \ Σ	0	1
→ A	D	B
B	C	E
C*	H	H
D	F	H
E	F	H
F	F	G
G*	H	H
H	H	H

let X be new state which is combine of D and E state and Y be new final state which is combine of C and G state

X = D and E   Y = C and G

Q \ Σ	0	1
→ A	X	B
B	Y	X
X	F	H
F	F	Y
Y*	H	H
H	H	H

Minimize DFA



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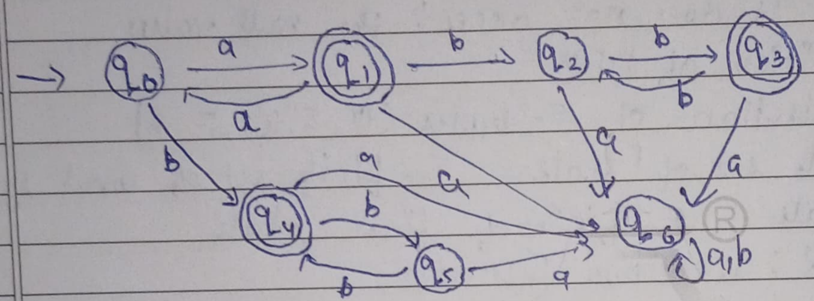
Q.2 b) Design a DFA for $L = \{a^m b^n / m+n = \text{odd}\}$

→ $L = \{a^m b^n / m+n = \text{odd}\}$　　$F = \{q_1, q_3, q_4\}$

$L = \{a, b, a^2b, ab^2, a^3, b^3 \ldots\ldots\}$



Q \ Σ	a	b
→ q_0	q_1	q_4
q_1^*	q_0	q_2
q_2	q_3	q_6
q_3^*	q_2	q_6
q_4^*	q_6	q_5
q_5	q_6	q_4
q_6	q_6	q_6

Example

→ (q_0, a^3b^2)
$\vdash (q_1, a^2b^2)$
$\vdash (q_0, ab^2)$
$\vdash (q_1, b^2)$
$\vdash (q_2, b)$
$\vdash (q_3, \epsilon)$
Hence it is accepted

→ (q_0, a^2b^2)
$\vdash (q_1, ab^2)$
$\vdash (q_0, b^2)$
$\vdash (q_4, b)$
$\vdash (q_5, \epsilon)$
Hence it is rejected.

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Q.3) Define NFA, DFA, Epsilon NFA

→ DFA → It refers to deterministic finite automata. In DFA, there is only path for specific input from the current state to the next state. It does not accept the null value

Formal Definition of DFA

It is a collection of 5-tuples $(Q, \Sigma, q_0, F, \delta)$

where Q: finite set of states Σ: finite set of input symbols

q_0: initial state F: ~~fix~~ Set of final state

δ: $Q \times \Sigma \rightarrow Q$: Transition Function

NFA → It refers to Non-deterministic finite Automata having zero, one or more than one moves from a given state on a given input symbols.

Formal Definition of NFA

It is collection of 5-tuples $(Q, \Sigma, q_0, F, \delta)$

where Q: finite set of states Σ: finite set of input symbols

q_0: initial state F: Set of final state

δ: $Q \times \Sigma \rightarrow 2^{Q}$ → Transition Function

Epsilon-NFA → It is the NFA which contains epsilon moves/null moves.

Formal Definition of ϵ-NFA

It is collection of 5 tuples $(Q, \Sigma \cup \epsilon, q_0, F, \delta)$

where Q: finite set of states $\Sigma \cup \epsilon$: finite set of input and ϵ move

q_0: initial state F: set of final state

δ: $Q \times \Sigma \cup \epsilon \rightarrow 2^{Q}$ → Transition function.

Q.5 a) Write the Regular Expression for the language accepting all the string which are starting and end with '1' over $\Sigma = \{0,1\}$

→ R.E = $1 \cdot (1+0)^* 1$

b) Write the regular expression for the language having a string which should not have consecutive two zeros

→ R.E = $(1+01)^* 0 + 0(1+10)^*$

c) Write the regular expression for the language having a string which should have atleast one 0 and atmost one 1

→ R.E = $(1 \cdot 0^* + 0^* 1 + 0^*) \cdot 0$

d) Write the regular expression for the language L over $\Sigma = \{0,1\}$ such that all $|W|_0 = 2 \bmod 3$