Academic Year (2021-22)
Year: 2 Semester: IV

Program: B. Tech. (Computer Engg.) **Max. Marks: 75**
Subject: Formal Language And Automata Theory **Time: 10: 30 am to 1:30 pm**
Date: 1st July 2022 **Duration: 3 Hours**

REGULAR EXAMINATION

ANSWER KEY

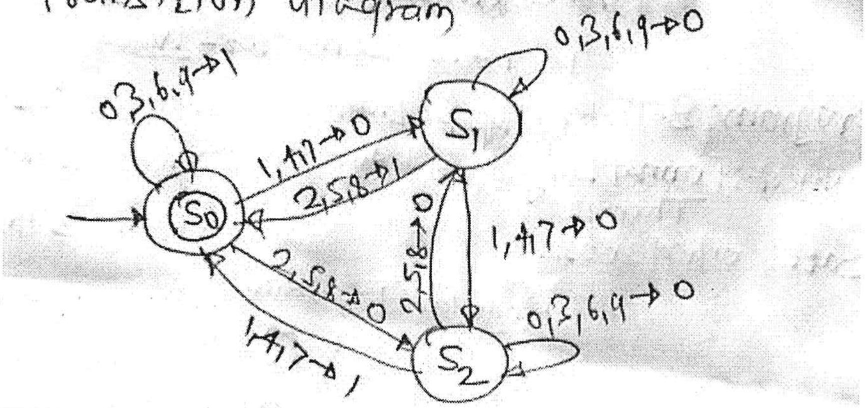
Question No.		Max. Marks
Q1 (a)	Assume 1. $I = \{0,1,2,3,4,5,6,7,8,9\}$ $I = \{(0,3,6,9)\ (1,4,7),\ (2,5,8)\}$ $S = \{S_0, S_1, S_2\}$ Where S_0 = for remainder 0 S_1 = for remainder 1 S_2 = for remainder 2 2. State function (STF) STF: $I \times S \to S$	[5]

S \ I	(0,3,6,9)	(1,4,7)	(2,5,8)
S_0	S_0	S_1	S_2
S_1	S_1	S_2	S_0
S_2	S_2	S_0	S_1

3. Machine function (MAF) MAF: $I \times S \to O$

S \ I	(0,3,6,9)	(1,4,7)	(2,5,8)
S_0	1	0	0
S_1	0	0	1
S_2	0	1	0

Transition diagram



Q1 (b) [10]

Present state	Next state			
	state I/P=0	O/P	state I/P=1	
→q_1	q_2	Z_1	q_3	Z_1
q_2	q_2	Z_2	q_3	Z_1
q_3	q_2	Z_1	q_3	Z_2

Transition table for mealy machine
from above transition table
q_2 state is associated with O/P→ Z_1 & Z_2
q_3 state is associated with O/P→ Z_1 & Z_2
q_1 state is associated with O/P → Λ
Assume
Split state q_2 — q_{21} → for O/P Z_1
— q_{22} → for O/P Z_2

Split state q_3 — q_{31} → for O/P Z_1
— q_{32} → for O/P Z_2

PS	NS			
	State i/p=0	o/p	State i/p=1	o/p
→ q_1	q_{21}	Z_1	q_{31}	Z_1
q_{21}	q_{22}	Z_2	q_{31}	Z_1
q_{22}	q_{22}	Z_2	q_{31}	Z_1
q_{31}	q_{21}	Z_1	q_{32}	Z_2
q_{32}	q_{21}	Z_1	q_{32}	Z_2

Revised transition table for mealy M/C

PS	NS		O/P
	i/p=0	i/p=1	
→ q_1	q_{21}	q_{31}	Λ
q_{21}	q_{22}	q_{31}	Z_1
q_{22}	q_{22}	q_{31}	Z_2
q_{31}	q_{21}	q_{32}	Z_1
q_{32}	q_{21}	q_{32}	Z_2

Transition table for moore M/C

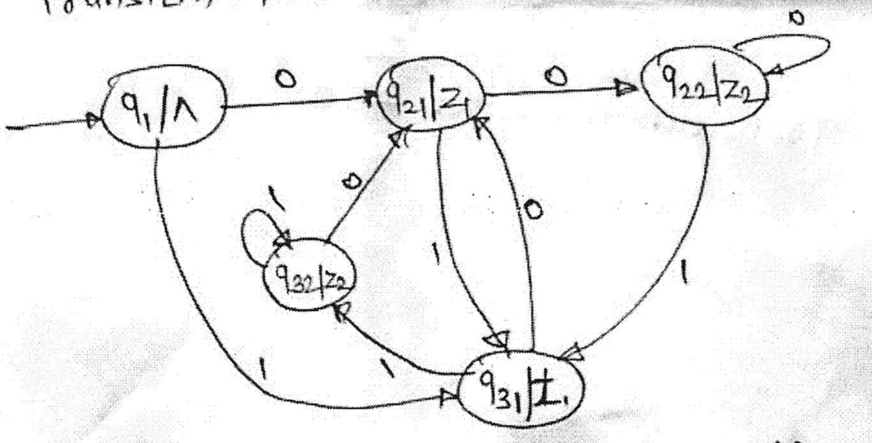


fig:- Transition diagram for moore M/C

Q1 (b) **OR** [10]

$\Pi_0 = \{\{q_3, q_4\}, \{q_0, q_1, q_2, q_5, q_6, q_7\}\}$

$\Pi_1 = \{\{q_3, q_4\}, \{q_0, q_6\}, \{q_1, q_2, q_5, q_7\}\}$

$\Pi_2 = \{\{q_3, q_4\}, \{q_0, q_6\}, \{q_1, q_2\}, \{q_5, q_7\}$

$\Pi_3 = \{\{q_3, q_4\}, \{q_0\}, \{q_6\}, \{q_1, q_2\}, \{q_5, q_7\}\}$

$\Pi_3 = \{\{q_0\}, \{q_1, q_2\}, \{q_3, q_4\}, \{q_5, q_7\}, \{q_6\}\}$

$S \backslash \Sigma$	a	b
$\{q_0\}$	$\{q_1, q_2\}$	$\{q_1, q_2\}$
$\{q_1, q_2\}$	$\{q_3, q_4\}$	$\{q_3, q_4\}$
$\{q_3, q_4\}$	$\{q_5, q_7\}$	$\{q_6\}$
$\{q_5, q_7\}$	$\{q_3, q_4\}$	$\{q_6\}$
$\{q_6\}$	$\{q_6\}$	$\{q_6\}$

Transition table for DFA

Q2 (a)	(i) Take 1st Production ~~st~~ rule $S \rightarrow ABC$ Assume $\boxed{R_1 \rightarrow BC}$ — ① $\therefore \boxed{S \rightarrow AR_1}$ — ② (ii) Take 2nd production rule $\boxed{A \rightarrow a}$ — ③ It is already in CNF (iii) Take 3rd production rule $\boxed{A \rightarrow b}$ — ④ It is already in CNF (iv) Take 4th production rule $B \rightarrow Bb$ Assume $\boxed{R_2 \rightarrow b}$ — ⑤ $\therefore \boxed{B \rightarrow BR_2}$ — ⑥ (v) Take 5th production rule $B \rightarrow aa$ Assume $\boxed{R_3 \rightarrow a}$ — ⑦ $\therefore \boxed{B \rightarrow R_3R_3}$ — ⑧ (vi) Take 6th production rule $C \rightarrow aC$ As $R_3 \rightarrow a$ $\therefore \boxed{C \rightarrow R_3C}$ — ⑨	[8]

(vii) Take 7th production rule

$C \to cC$

Assume $\boxed{R_4 \to c}$ —— (10)

$\therefore \boxed{C \to R_4 C}$ —— (11)

(viii) Take 8th production rule

$C \to ba$

As $R_2 \to b$

& $R_3 \to a$

$\therefore \boxed{C \to R_2 R_3}$ —— (12)

$\therefore$ The final grammar in CNF is as follows

(i) $R_1 \to BC$	(v) $R_2 \to b$	ix) $C \to R_3 C$
(ii) $S \to AR_1$	(vi) $B \to BR_2$	x) $R_4 \to c$
(iii) $A \to a$	(vii) $R_3 \to a$	xi) $C \to R_4 C$
(iv) $A \to b$	(viii) $B \to R_3 R_3$	xii) $C \to R_2 R_3$

Q2 (b) [7]

Marks - 07

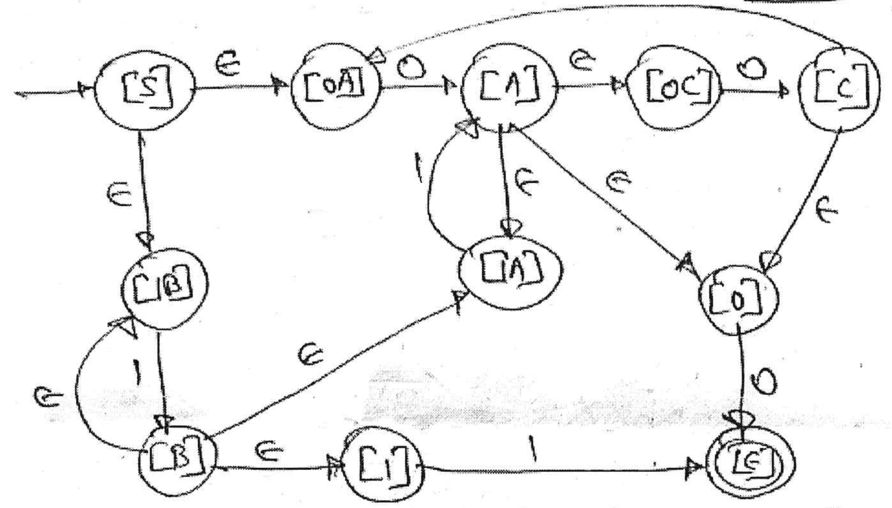


Fig:- NFA with 'ε' moves drawn for GR

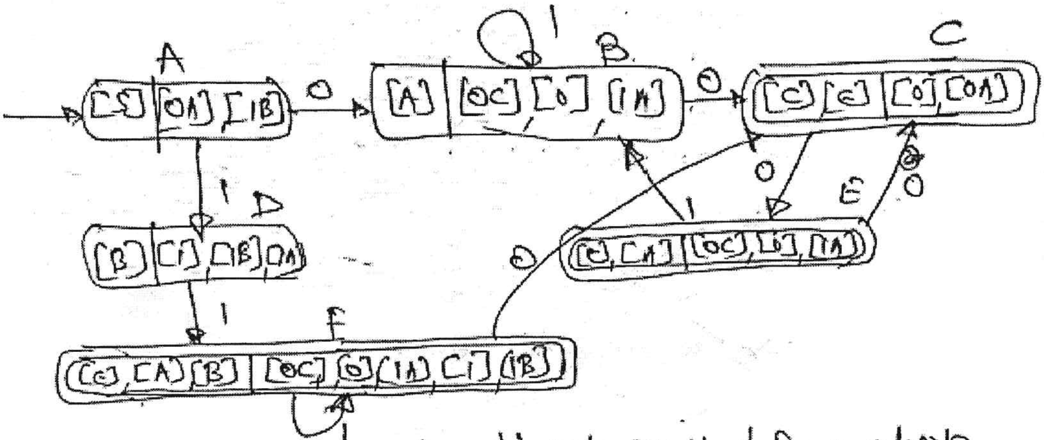


Fig:- DFA obtained by direct method from above NFA with ε moves.

S \ Σ	0	1
→A	B	D
B	C	B
C	E	-
D	-	F
E	C	B
F	C	F

Transition table for DFA

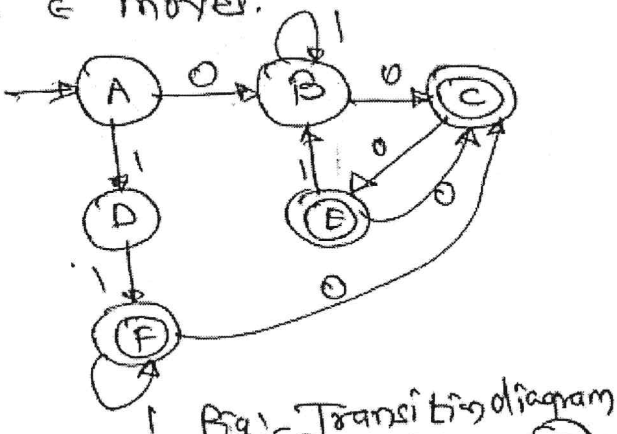


Fig:- Transition diagram for DFA

7

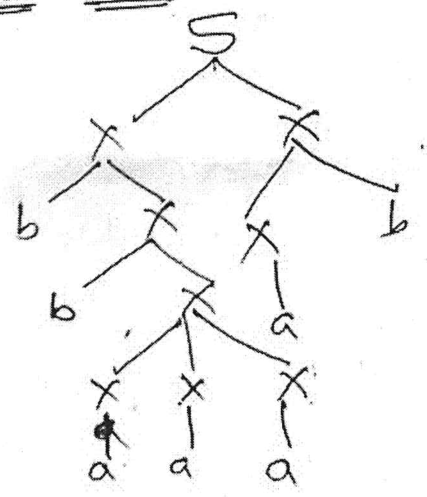
OR [7]

1) $S \rightarrow XX$
2) $X \rightarrow XXX$
3) $X \rightarrow bX$
4) $X \rightarrow Xb$
5) $X \rightarrow a$

LMD

$S \rightarrow XX$ — 1
$\rightarrow bXX$ — 3
$\rightarrow bbXX$ — 3
$\rightarrow bbXXXX$ — 2
$\rightarrow bbaXXX$ — 5
$\rightarrow bbaaXX$ — 5
$\rightarrow bbaaaX$ — 5
$\rightarrow bbaaaXb$ — 4
$\rightarrow bbaaaab$ — 5

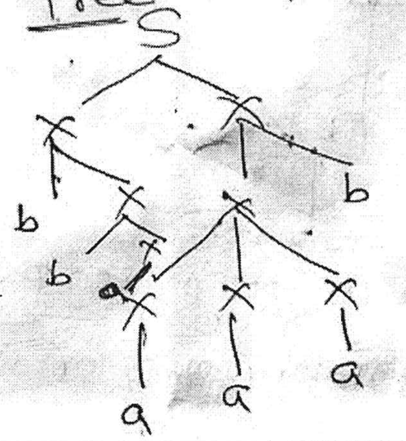
LMD Tree



<u>RMD</u>

S → XX — 1
→ XXb — 4
→ XXXXb — 2
→ XXXab — 5
→ XXaab — 5
→ Xaaab — 5
→ bXaaab — 5
→ bbXaaab — 5
→ bbaaaab — 5

<u>RMD Tree</u>



Q3 (a) [7]

pictorial representation with simulation of String —— marks — (07)

The language can be listed as follows.

L = {ε, aa, bb, aaaa, abba, baab, bbbb, aaaaaa, bbbbbb-----}

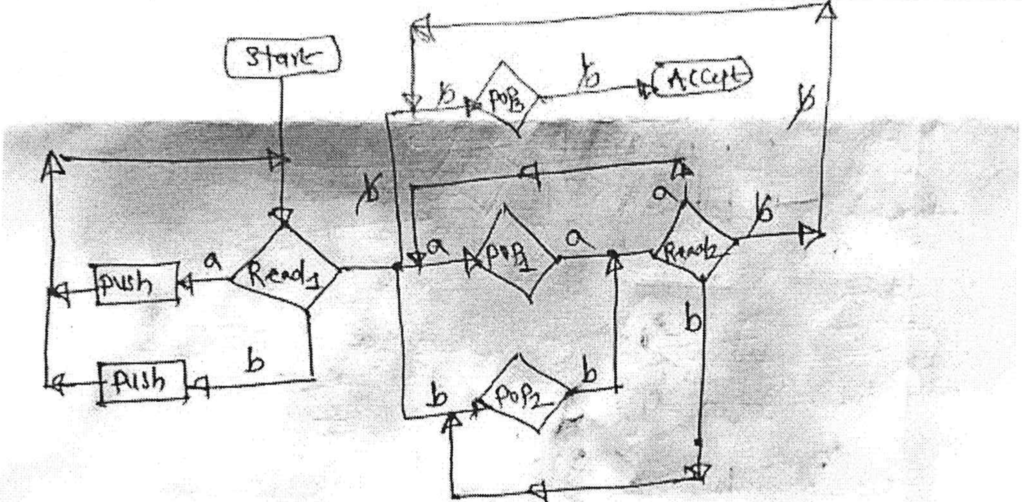


Fig:- PDA accepting even palindrome

Simulation of any string of even palindrome of a's & b's

Example

Current state	Stack of contents	Tape & Head
Start	ƀ	abbaƀƀ
↓ Read1	ƀ	abbaƀƀ
a↓ Pusha	ƀa	abbaƀƀ
↓ Read1	ƀa	abbaƀƀ
b↓ Push b	ƀab	abbaƀƀ
Pop2	ƀa	~~abbaƀƀ~~ (10)
↓b Read1	ƀab	abbaƀƀ
↓a Pop2	ƀa	abbaƀƀ
↓b Read2	ƀa	abbaƀƀ
↓a Pop1	ƀ	abbaƀƀ
↓a Read2	ƀ	abbaƀƀ
↓ƀ Pop3	—	abbaƀƀ
Accept		

Q3 (a) **OR** [7]

pictorial representation of simulation marks of

S → S+S
→ 4+S
→ 4+S*S
→ 4+4*S
→ 4+4*S

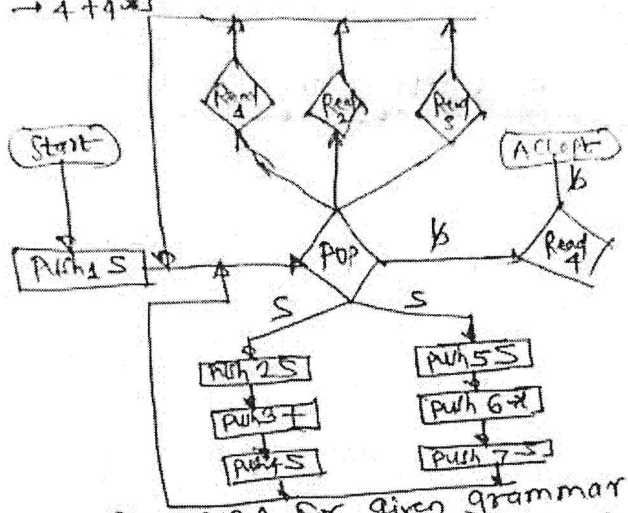


fig:- PDA for given grammar which
simulation for the string 4+4~~*4~~
grammar

Q3 (b) [8]

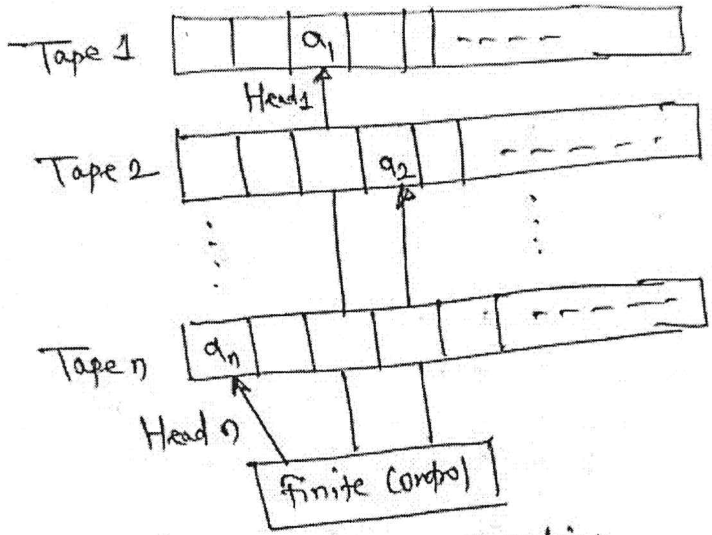
S \ I	(0,3,6,9)	(1,4,7)	(2,5,8)	B
q_0	q_0RX	q_1RY	q_2RZ	q_3RB
q_1	q_1RX	q_2RY	q_0RZ	q_4RB
q_2	q_2RX	q_0RY	q_1RZ	q_5RB
q_3	—	—	—	q_6N0
q_4	—	—	—	q_6N1
q_5	—	—	—	q_6N2
q_6	Accept	Reject	Reject	—

Assume: $I = \{0,1,2,3,4,5,6,7,8,9\}$
q_0 – for remainder 0 , X — for (0,3,6,9)
q_1 – for remainder 1   Y — for (1,4,7)
q_2 – for remainder 2   Z – for (2,5,8)

	BB123BBB q_0 BB 23BBB q_1 BB123BBB q_1 BB123BBB q_0 BB123BBB q_0 BB123BBB q_0 BB123BBB q_0 BB123BBB q_0 BB123BBB q_3 BB123BB q_6 Accept	
Q4 (a)	Q.4 (a) Given: $n > 0$ marks - (10) (1) for $n=1$ length is $= 3$ $n=2$ — " — $= 5$ $n=3$ — " — $= 7$ from above each string generates the odd length of string sequence (2) Let the given ~~grammar~~ ~~of~~ language is $L = \{a^n b^{n+1} \mid n > 0\}$ is regular (3) Let 'l' be a pumping Lemma constant (4) Let 'z' be as $a^l b^{l+1}$ So $\|z\| = l+l+1$ $\|z\| = 2l+1$ (5) By pumping lemma $z = uvw$ for $1 \le \|v\| \le l$ for $i \ge 0$ then uv^iw is in L (6) Let $i = 2$ $1 \le \|v\| \le l$ $2l+1+1 \le \|uv^2w\| \le l+2l+1$ $2l+2 \le \|uv^2w\| \le 3l+1$ (7) $2l+1 < \|uv^2w\| < 3l+2$ let $l = 1$ $2 \times 1 + 1 < \|uv^2w\| < 3 \times 1 + 2$ $3 < \|uv^2w\| < 5$ We got value as <u>4</u> This value is <u>even</u>	[10]

	Let $i=2$ $2\times2+1 < \lvert uv^2w\rvert < 3\times2+2$ $5 < \lvert uv^2w\rvert < 8$ we got value as 6 & 7 it is not odd Then length of uv^2w is not always odd, that means uv^2w is not in 'L'. so, that the given language $\{a^n b^{n+1} \mid n>0\}$ is not regular	
Q4(a)	**OR** We get the following equations $q_0 = \Lambda$ — (1) $q_1 = q_0 1 + q_1 1 + q_3 1$ — (2) $q_2 = q_1 0 + q_2 0 + q_3 0$ — (3) $q_3 = q_2 1$ — (4) $q_2 = q_1 0 + q_2 0 + q_2 10$ $= q_1 0 + q_2(0+10)$ By Arden's Th. $\boxed{q_2 = q_1 0\,(0+10)^*}$ Now $q_1 = 1 + q_1 1 + q_2 11$ $= 1 + q_1 1 + q_1 0\,(0+10)^* 11$ $q_1 = 1 + q_1 (1 + 0(0+10)^* 11)$ By Arden's Th. $\boxed{q_1 = 1\,(1+0(0+10)^* 11)^*}$	[10]

	$q_3 = q_2 1$ $q_3 = 1(1+0(0+10)11)^* 0(0+10)^* 1$ $\boxed{\therefore q_3 = 1(1+0(0+10)11)^* 0(0+10)^* 1}$	
Q4 (b)	$= \Lambda + 1^*(011)^*(1^*(011)^*)^*$ $= \Lambda + P_1 P_1^*$ (where $P_1 = 1^*(011)^*$ $= P_1^*$ using I_9 $= (1^*(011)^*)^*$ $= (P_2^* P_3^*)^*$ let $P_2 = 1$, $P_3 = 011$ $= (P_2 + P_3)^*$ using I_{11} $= (1 + 011)^*$	[5]
Q5 (a) (i)	Q.5 (a) i) **DPDA** / **NPDA** DPDA: 1) It is less powerful than NPDA. — NPDA: 1) It is more powerful than DPDA DPDA: 2) It is possible to convert every DPDA to a corresponding NPDA. — NPDA: 2) It is not possible to convert every NPDA to a corresponding DPDA. DPDA: 3) The language accepted by DPDA is a subset of the language accepted by NPDA. — NPDA: 3) The language accepted by NPDA is not a subset of the language accepted by DPDA DPDA: 4) The language accepted by DPDA is DCFL. — NPDA: 4) The language accepted by NPDA is called NCFL.	[5]

Q5 (a) (ii)	ii) Explanation with example	[5]
Q5 (a) (iii)	Q.5 marks - 05 (a) (b) (iii) There are two types of Turing Machine 1) multitape Turing machine 2) Nondeterministic Turing machine 1) multitape TM  fig:- multitape Machine 2) Non-deterministic TM A non-deterministic TM M is seven tuple given below $M = (Q, \Sigma, \Gamma, \delta, q_0, B, F)$ where Q: finite set of states of TM Γ: finite set of symbols called tape symbols. Σ: nonempty subset of Γ called i/p symbols. q_0: initial state B: Blank symbol $F \subseteq Q$ called as set of final state	[5]

	δ - defined a mapping from ~~Q×~~ $Q \times \Gamma$ to $Q \times \Gamma \times \{L, R, N\}$	
Q5 (b)	1) Delete all 'ε' productions from given grammar G. After deleting 'ε' productions we get $\boxed{\begin{array}{l} S \rightarrow Xa \\ X \rightarrow aX \\ X \rightarrow bX \end{array}}$ —— 1 2) Identify nullable non-terminal in the given grammar $\boxed{X \rightarrow \epsilon}$ so 'X' is a nullable non-terminal 3) Identify nullable non-terminal which should occur on right hand side of the production rule. $S \rightarrow Xa$ $X \rightarrow aX$ $X \rightarrow bX$ After putting value of 'X' as 'null' we get new production rule as $\boxed{\begin{array}{l} S \rightarrow a \\ X \rightarrow a \\ X \rightarrow b \end{array}}$ —— 2 4) So the final grammar G as $\boxed{\begin{array}{l} S \rightarrow Xa \mid a \\ X \rightarrow aX \mid a \\ X \rightarrow bX \mid b \end{array}}$	[5]