Ans:- 1b Transition Table of Given Mealy Machine:-

	a = 0		a = 1	
	State	Output	State	Output
→ q_1	q_1	1	q_2	0
q_2	q_4	1	q_4	1
q_3	q_2	0	q_3	1
q_4	q_3	0	q_2	1

Conversion to moore machine :-

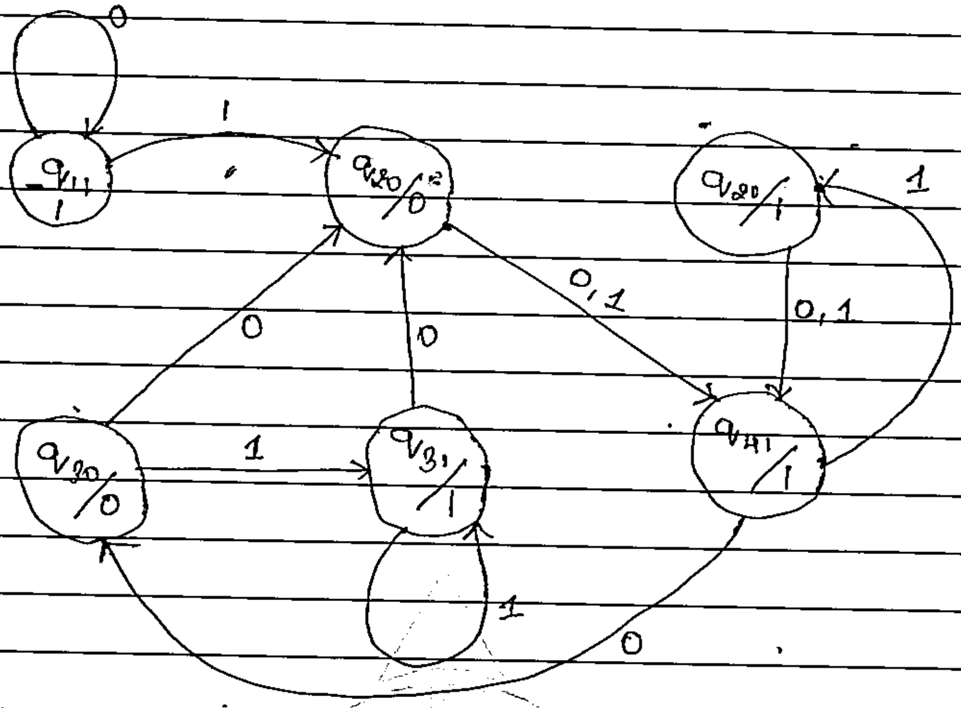
Transition table

	a	b	Output
q_1			
q_2			
q_3			
q_4			

Transition table

	a=0	a=1	Output
q_{11}	q_{11}	q_{20}	1
q_{20}	q_{41}	q_{41}	0
q_{21}	q_{41}	q_{41}	1
q_{30}	q_{20}	q_{31}	0
q_{31}	q_{20}	q_{31}	1
q_{41}	q_{30}	q_{21}	1

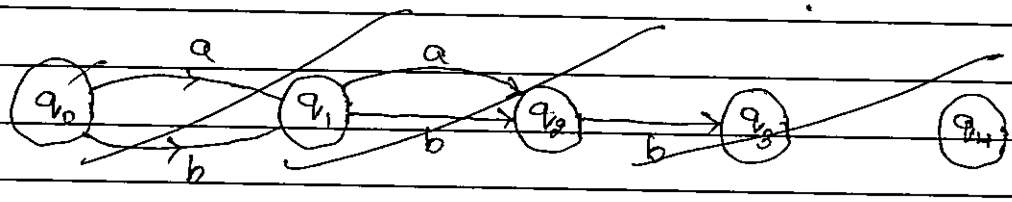
Now, Moore Machine

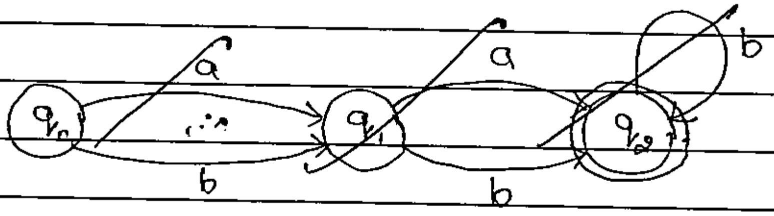


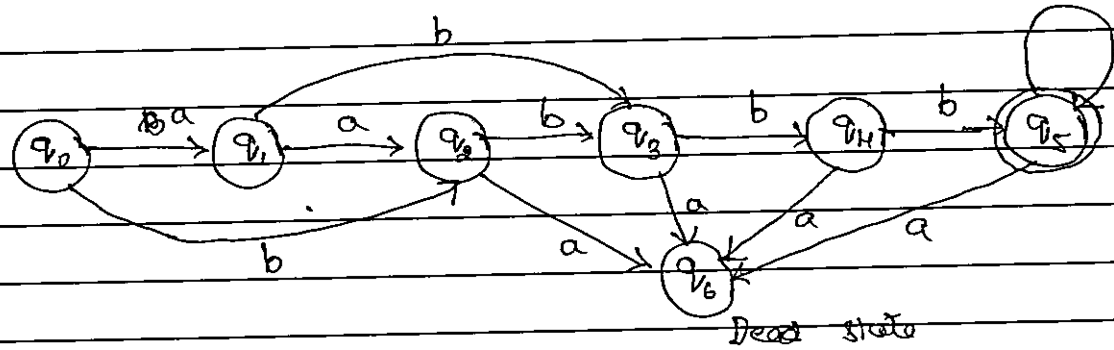
Ans

Ans 1d $L = \{ w$ where number of a in $w = 2$ and number of b in $w \geq 3 \}$

$L = \{$ aabbb , aabbbb , abbba , ... $\}$







Transition table

input / states	a	b
q_0	q_1	q_2
q_1	q_2	q_3
q_2	q_6	q_3
q_4	q_6	q_5
q_5	q_6	q_5

P. T. O.

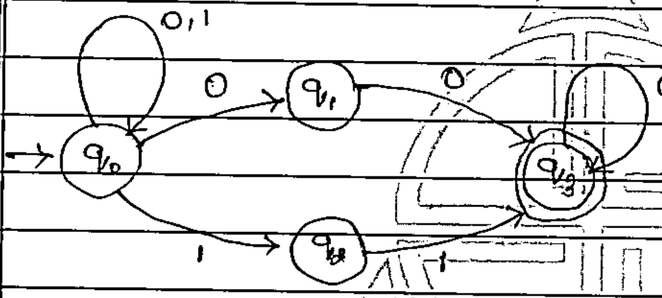
Ans:- 2b We have

$$R.E. \Rightarrow (0+1)^* (00+11) (0+1)^*$$

So accepted inputs

$$L = \{ 00, 11, 0000, 1111, \ldots \}$$

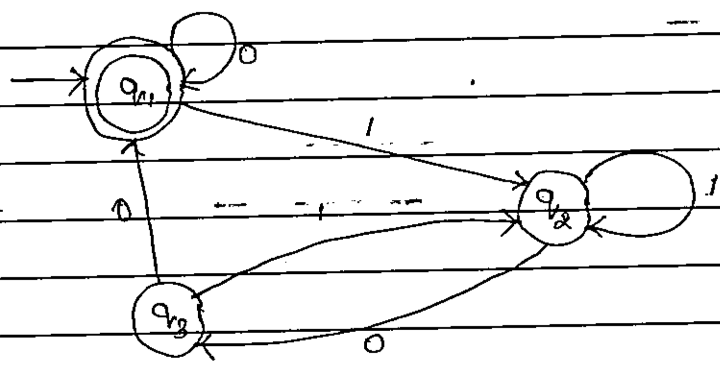
Now, finite automata :-



Transition table

	0	1
q_0	$\{q_0, q_1\}$	$\{q_0, q_2\}$
q_1	q_3	ϕ
q_2	ϕ	q_3
q_3	q_3	q_3

Ans:- 2d



Equations :-

$$q_1 = \epsilon + q_1 0 + q_3 0 \quad \text{——} \quad (1)$$
$$q_2 = q_1 1 + q_2 1 + q_3 1 \quad \text{——} \quad (2)$$
$$q_3 = q_2 0 \quad \text{——} \quad (3)$$

put Eq^n (3) in Eq^n (2) :-

$$q_2 = q_1 1 + q_2 1 + (q_2 0) 1$$
$$\Rightarrow q_2 = q_1 1 + q_2 1 + q_2 01$$
$$\Rightarrow q_2 = q_1 1 + q_2 (1 + 01)$$

Applying Arden's theorem, we get

$$q_2 = q_1 1 (1 + 01)^* \quad \text{——} \quad (4)$$

Now put Eq^n (3) in Eq^n (1)

$$q_1 = \epsilon + q_1 0 + (q_2 0) 0$$
$$\Rightarrow q_1 = \epsilon + q_1 0 + q_2 00 \quad \text{——} \quad (5)$$

Now, put Eq^n (4) in Eq^n (5)

$$q_1 = \epsilon + q_1 0 + q_1 1 (1 + 01)^* 00.$$

$$\Rightarrow q_1 = \epsilon + q_1[0 + 1(1+01)^* 00]$$

Applying Arden's theorem,
we get

$$q_1 = \epsilon \cdot [0 + 1(1+01)^* 00]^*$$

$$\Rightarrow q_1 = [0 + 1(1+01)^* 00]^*$$

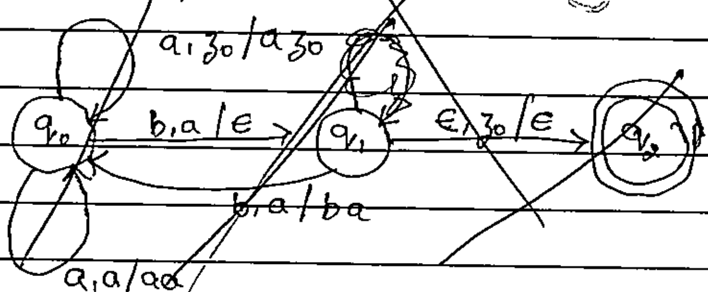
Ans

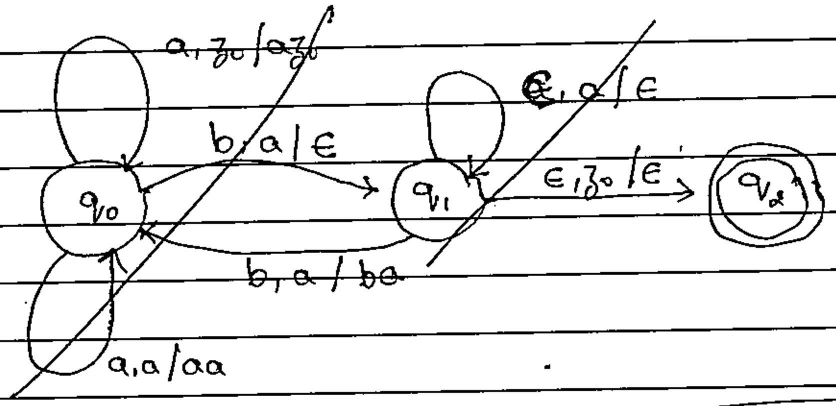
Ans:- 4b $L = \{a^n b^{2n}, n \geq 1\}$

$\Rightarrow L = \{abb, aabbbb, aaabbbbbb, \ldots\ldots\}$

aabbbb

PDA →

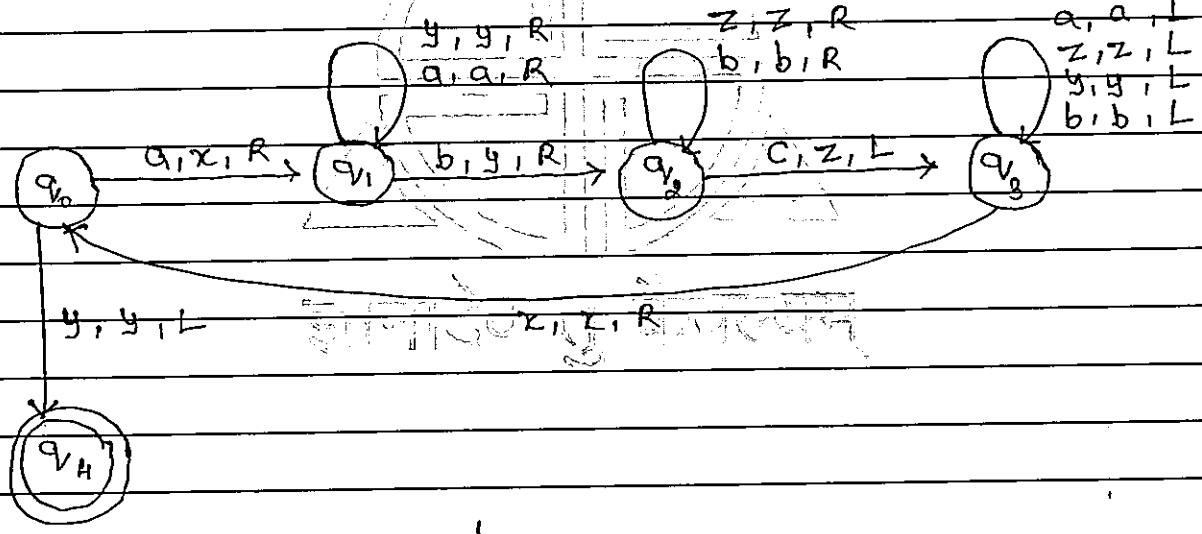




Ans:- 4c $L = \{ a^n b^n c^n \ , \ n \geq 0 \}$

for n = 3

aaabbbccc



Ans

Transitions

$\delta(q_0, a) \rightarrow (q_1, x, R)$

$\delta(q_1, a) \rightarrow (q_1, a, R)$

$\delta(q_1, y) \rightarrow (q_1, y, R)$

$\delta(q_1, b) \rightarrow (q_2, y, R)$

$\delta(q_2, b) \rightarrow (q_2, b, R)$

$\delta(q_2, z) \rightarrow (q_2, Z, R)$
$\delta(q_2, c) \rightarrow (q_3, Z, L)$
$\delta(q_3, a) \rightarrow (q_3, a, L)$
$\delta(q_3, z) \rightarrow (q_3, z, L)$
$\delta(q_3, y) \rightarrow (q_3, y, L)$
$\delta(q_3, b) \rightarrow (q_3, b, L)$
$\delta(q_0, y) \rightarrow (q_4, y, L)$

Ans:- 4 (i) Decidable and Undecidable problem

Decidable problem :-

A given problem is decidable if there exists a turing machine which will halt for every input and give output accepted or rejected.
Recursive problems are decidable as there exists a Turing machine for it.

Undecidable problem :-

A undecidable problem is a problem which is not decidable, i.e. there does not exist any turing machine which will halt for any input and give output as accepted and ~~reg~~ rejected.

(8) Halting Problem of Turing Machine :-

Halting problem ~~&~~ in turing machine is a situation where for a certain input, the turing machine runs forever and never halts.
There are some inputs which keeps ~~then~~ calling themselves recursively which causes the halting problem of Turing machine.

Ans:- 5b : We have

$$f(x, y) = x * y$$

$$f(x, 0) = 0$$

In the form of zero function

Now $f(x, y+1) = x*(y+1)$
$= x*y + x$
$= f(x, y) + x$

In successor fun form

$$= U_3^3(x, y, f(x,y)) + U_1^3(x, y, f(x,y))$$

In projector function form

Since, we know that Additive function is primitive recursive

So $f(x,y) = x * y$ is primitive recursive

Now for $f(x,y) = x^y$

$$f(x,0) = x^0 = 1$$

$$f(x, y+1) = x^{y+1} = x^y \times x = f(x,y) \times x$$

$$= U_3^3(x, y, f(x,y)) \times U_1^3(x, y, f(x,y))$$

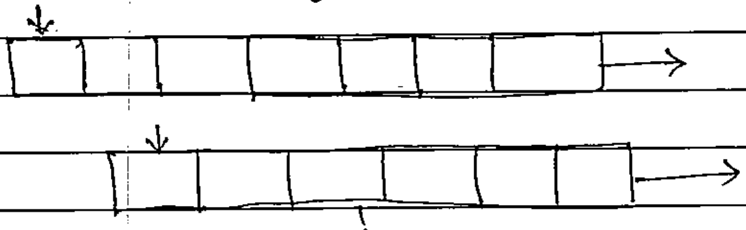
Since we've proved above that multiplicative function is primitive recursive

so $f(x,y) = x^y$ is primitive recursive

proved

Ans c :- **Time Complexity :-**

Suppose there are n tapes in a turing machine.



for n number of inputs, the turing machine will execute at most n times.

So Time complexity $T(n) = O(n)$

Space Complexity :-

It is the amount of space turing machine will require for execution of n inputs.

we have $S(n) = O(n)$

P. T. O.

Ans:- 30

$E \to E + T / T$
$T \to T * F / F$
$F \to (E) / a$

firstly we will convert it in CNF.

Step 1 Introduce $S_0 \to S E$
So new productions

$S_0 \to S E$
$E \to E + T / T$
$T \to T * F / F$
$F \to (E) / a$

Step 2, 3 Removal of null and unit productions.
We have unit productions
$S_0 \to S$, $E \to T$, & $T \to F$

(i) $T \to F$
here $F \to (E) / a$
so $T \to (E) / a$
Remove $T \to F$

(ii) $E \to T$
here $T \to T * F / (E) / a$
so $E \to T * F / (E) / a$
Remove $E \to T$

(viii) $S_0 \rightarrow E$

here $E \rightarrow E + T / T * F / (E) / a$

so $S_0 \rightarrow E + T / T * F / (E) / a$

Remove $S_0 \rightarrow E$

Production

$S_0 \rightarrow E + T / T * F / (E) / a$

$E \rightarrow E + T / T * F / (E) / a$

$T \rightarrow T * F / (E) / a$

$F \rightarrow (E) / a$

Step 4 Reduction

Phase I : $T = \{+, *, (,), a\}$

$W_1 = \{S_0, E, T, F\}$

$W_2 = \{S_0, E, T, F\}$

$W_1 = W_2$

$G' = (\{S_0, E, T, F\}, \{+, *, (,), a\}, S_0, P)$

* Production

$S_0 \rightarrow E + T / T * F / (E) / a$

$E \rightarrow E + T / T * F / (E) / a$

$T \rightarrow T * F / (E) / a$

$F \rightarrow (E) / a$

Phase II : $Y_1 = \{S_0\}$

$Y_2 = \{S_0, E, +, T, *, F, (, E,), a\}$

$Y_3 = \{S_0, E, +, T, *, F, (, E,), a\}$

$Y_2 = Y_3$

$G^n = (\{S_0, E, T, F\}, \{+, *, (,), a\}, S_0, P)$

• Production ⇒

$S_0 \rightarrow E + T \ / \ T * F \ / \ (E) \ / \ a$
$E \rightarrow E + T \ / \ T * F \ / \ (E) \ / \ a$
$T \rightarrow T * F \ / \ (E) \ / \ a$
$F \rightarrow (E) \ / \ a$

Step 5 :- Convert if ~~...~~ terminal & non terminal exists together and if more that two Non terminal exist together.

$S_0 \rightarrow E + T$ $\quad\quad$ $S_0 \rightarrow T * F$
$S_0 \rightarrow E X$ $\quad\quad$ $S_0 \rightarrow T Z$
$X \rightarrow + T$ $\quad\quad$ $Z \rightarrow * F$
$X \rightarrow Y T$ $\quad\quad$ $Z \rightarrow P F$
$Y \rightarrow +$ $\quad\quad$ $P \rightarrow *$

$S_0 \rightarrow (E)$
$S_0 \rightarrow A Q$
$Q \rightarrow E)$
$A \rightarrow ($
$Q \rightarrow E B$
$B \rightarrow)$

So Production $\longrightarrow$

$S_0 \rightarrow EX \mid TZ \mid AQ \mid a$

$E \rightarrow EX \mid TZ \mid AQ \mid a$

$T \rightarrow TZ \mid AQ \mid a$

$F \rightarrow AQ \mid a$

$X \rightarrow YT$

$Y \rightarrow +$

$Z \rightarrow PF$

$P \rightarrow *$

$A \rightarrow ($

$Q \rightarrow EB$

$B \rightarrow)$

This is CNF

Now Conversion to GNF

Step 1 :- Let $S_0 = A_1$

~~$S_0 \rightarrow A$~~ $E \rightarrow A_2$

$X \rightarrow A_3$

$T \rightarrow A_4$

$Z \rightarrow A_5$

$A \rightarrow A_6$

$Q \rightarrow A_7$

$F \rightarrow A_8$

$Y \rightarrow A_9$

$P \rightarrow A_{10}$

$B \rightarrow A_{11}$

Production

$A_1 \rightarrow A_2 A_3 \mid A_4 A_5 \mid A_6 A_7 \mid a$ — (1)

$A_2 \rightarrow A_2 A_3 \mid A_4 A_5 \mid A_6 A_7 \mid a$ — (2)

$A_4 \rightarrow A_4 A_5 \mid A_6 A_7 \mid a$ — (3)

$A_8 \rightarrow A_6 A_7 \mid a$ — (4)

$A_3 \rightarrow A_9 A_4$ — (5)

$A_9 \rightarrow +$ — (6)

$A_5 \rightarrow A_{10} A_8$ — (7)

$A_{10} \rightarrow *$ — (8)

$A_6 \rightarrow ($ — (9)

$A_7 \rightarrow A_2 A_{11}$ — (10)

$A_{11} \rightarrow)$ — (11)

Put Eq^n (9) in Eq^n (2)

$A_2 \rightarrow \underbrace{A_2 A_3}_{\alpha_1} \mid \underbrace{A_4 A_5}_{\beta_1} \mid \underbrace{(A_7}_{\beta_2} \mid \underbrace{a}_{\beta_3}$

Now left recursion

$Z \rightarrow A_3 \mid A_3 Z$

$A_2 \rightarrow A_4 A_5 \mid (A_7 \mid a \mid A_4 A_5 Z \mid (A_7 Z \mid aZ$

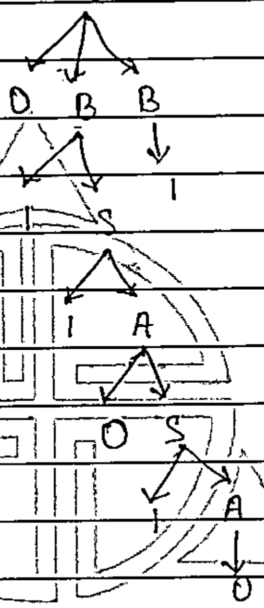
Ans 3d $S \rightarrow 0B \mid 1A$

$A \rightarrow 0 \mid 0S \mid 1AA$

$B \rightarrow 1 \mid 1S \mid 0BB$

LMD string = 00110101

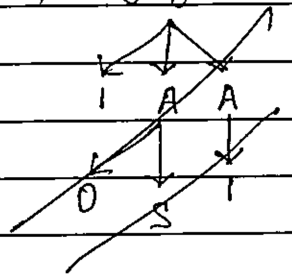
$S \rightarrow 0B$



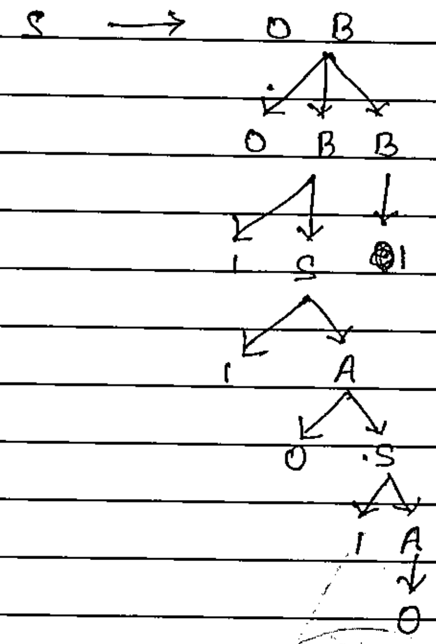
~~RMD~~

~~string = 00110101~~

~~$S \rightarrow 0B$~~



RMD



Ans

Ans:- 1a

NFA	DFA
→ It stands for Non Deterministic finite Automata.	It stands for Deterministic finite automata.
→ It can have more than one transition state for the same input	It cannot have more than one transition state for same input.
→ It can contain ε; i.e. ε - NFA	It cannot have ε.

Ans 2g Closure property of regular grammers gives the infinite repetion of elements.

Eg :- $(a)^* = \{e, a, aa, \dots\}$

$a^+ \rightarrow \{a, aa, aaa, \dots\}$

Ans 3a (i) $L = \{$ odd number of 1's $\}$

$L = \{1, 0111, 0111110, \dots\}$

R.E. =

(ii) $L = \{$ strings ending with 00 $\}$

$L = \{00, 100, 110100, \dots\}$

R.E. $= (0+1)^*00$

Ans 5a :- A function is an initial function if it is any of

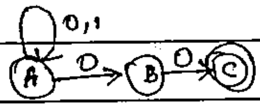
(i) Zero function.

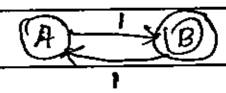
(ii) Successor function.

(iii) Projector function.

Partial function :- A function is partial function if it is defined for some of its arguments.

Rough





Ans: 3b A Grammer is in Chomsky Normal form if it satisfies the following condition :

(i) A non terminal generates Epsilon.
(ii) A non terminal generates two non terminal.
(iii) A non terminal generates one terminal.

Eg :- $S \rightarrow \epsilon$

$A \rightarrow AB$

$A \rightarrow b$

The above productions are in CNF.

We can convert a given context free grammer into Chomsky Normal form by following steps :

Step 1 : Replace the start symbol S with a new start symbol $S_0 \rightarrow S$.

Step 2 : Simplify the given context free grammer which includes:
(a) Removal of null productions
(b) Removal of unit productions
(c) Reduction.

Step 3: Convert the productions which contains more than two non-terminals or more than ~~two~~ one terminal or a terminal with a non terminal.

Ans 4a:

NPDA	DPDA
NPDA stands for Non Deterministic push down auto automata.	DPDA stands for Deterministic push down automata.
~~The~~ ~~I~~ NPDA accepts movable strings.	D does not accepts movable strings.

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