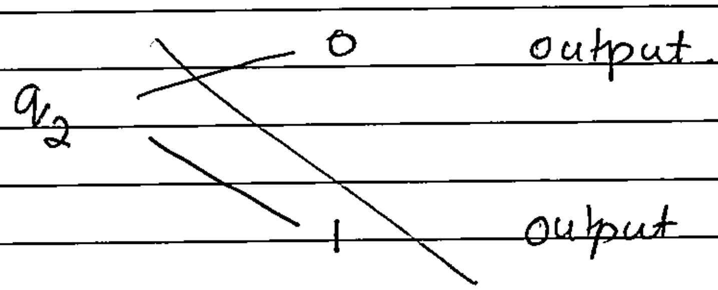
Q1a) DFA	NFA
i) DFA is deterministic finite automata	i) NFA stands for non deterministic finite automata
ii) ~~A~~ It takes more space	ii) It takes less space
iii) Time to construct a DFA is more	iii) Time to construct a NFA is less
iv) Dead end is required	iv) Dead end is not required.

Q1b) Melay ~~malay~~ machine

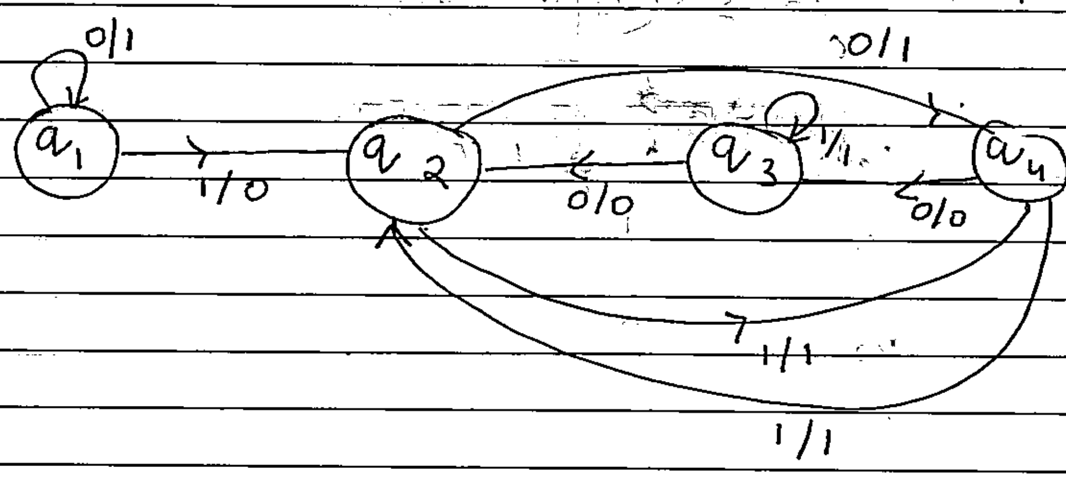
	a=0		a=1	
	state	output	state	output
q_1	q_1	1	q_2	0
q_2	q_4	1	q_4	1
q_3	q_2	0	q_3	1
q_4	q_3	0	q_2	1.



q_3 0 output

1 output.

	0	1	output
q_1	q_{11}	q_{21}	1
q_{21}	q_{41}	q_{41}	1
q_{41}	q_{30}	q_{21}	1
q_{30}	q_{20}	q_{31}	0
q_{20}	q_{41}	q_{41}	0
q_{31}	q_{20}	q_{31}	1



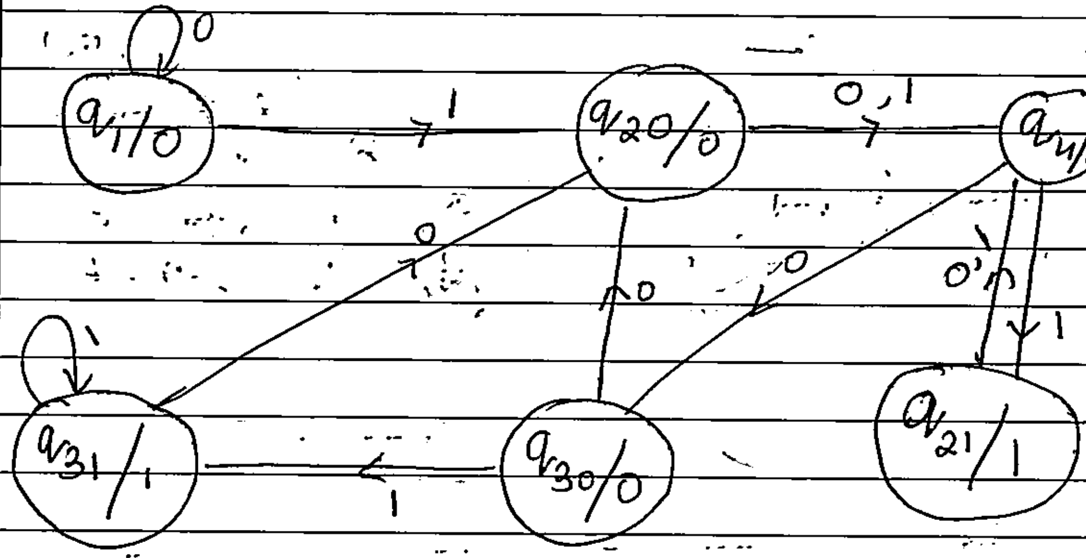
Mealy machine.

For moore :-

q_2 — 0 output
q_2 — 1 output

q_3 — 0 output
q_3 — 1 output

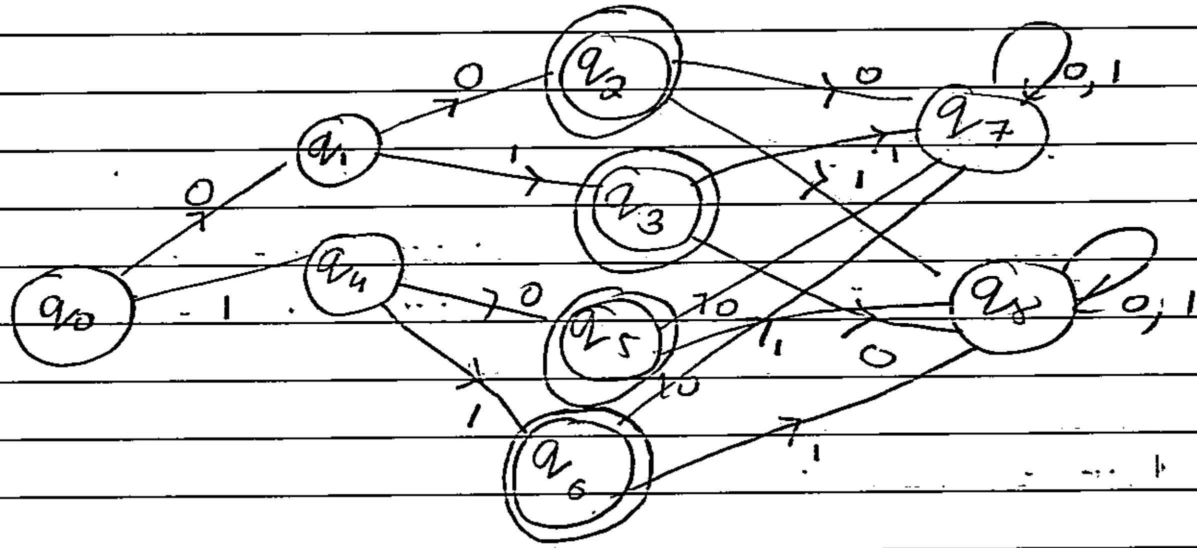
	0	1	output
q_1	q_1	q_{20}	1
q_{20}	q_4	q_4	0
q_4	q_{30}	q_{21}	1
q_{21}	q_4	q_4	1
q_{30}	q_{20}	q_{31}	0
q_{31}	q_{20}	q_{31}	1



Moore machine

Q1 c)

	q_0	q_1	q_2	q_3	q_4	q_5	q_6	q_7
q_1	✓							
q_2		✓						
q_3		✓						
q_4	✓							
q_5					✓			
q_6					✓			
q_7			✓	✓		✓	✓	
q_8			✓	✓		✓	✓	



~~pari~~ paired not marked :-

(q_0, q_1)
(q_0, q_2)
(q_0, q_3)
(q_0, q_4)
(q_0, q_5)
(q_0, q_6)
(q_0, q_7)
(q_0, q_8)
(q_1, q_4)
(q_1, q_5)
(q_1, q_6)
(q_1, q_7)
(q_1, q_8)
(q_2, q_3)
(q_2, q_4)
(q_2, q_5)
(q_2, q_6)
(q_3, q_4)
(q_3, q_5)
(q_3, q_6)

(q_4, q_7)
(q_4, q_8)
(q_5, q_6)
(q_7, q_8)

Now solving for (q_0, q_1)

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_1, 0) = q_2$ $\delta(q_1, 1) = q_3$

as (q_1, q_2) is marked, we will also mark q_0, q_1

for (q_0, q_2)

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_2, 0) = q_7$ $\delta(q_2, 1) = q_8$.

for,
(q_0, q_3)

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_3, 0) = q_8$ $\delta(q_3, 1) = q_7$

for (q_0, q_4)

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_4, 0) = q_5$ $\delta(q_4, 1) = q_6$

$q_4\ q_6$ is marked so q_0, q_4 will also be marked.

for (q_0, q_5)

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_5, 0) = q_7$ $\delta(q_5, 1) = q_8$

for (q_0, q_6)

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$

$\delta(q_6, 0) = q_2$ $\delta(q_6, 1) = q_8$

for (q_0, q_7)

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_7, 0) = q_2$ $\delta(q_7, 1) = q_7$

For (q_0, q_8) ~~q_{4}~~

$\delta(q_0, 0) = q_1 \quad \delta(q_0, 1) = q_4$
$\delta(q_8, 0) = q_8 \quad \delta(q_8, 1) = q_8$

For (q_1, q_4)

$\delta(q_1, 0) = q_2 \quad \delta(q_1, 1) = q_3$
$\delta(q_4, 0) = q_5 \quad \delta(q_4, 1) = q_6$

For (q_1, q_5)

$\delta(q_1, 0) = q_2 \quad \delta(q_1, 1) = q_3$
$\delta(q_5, 0) = q_7 \quad \delta(q_5, 1) = q_8$

~~So Red (q~~

Now again unmarked pair.

(q_0, q_2) (q_2, q_3) ~~For (q_0, q_2)~~
(q_0, q_3) (q_2, q_4)
(q_0, q_5) (q_2, q_5)
(q_0, q_6) (q_2, q_6)
(q_0, q_7) (q_3, q_4)
(q_0, q_8) (q_3, q_5)
(q_1, q_4) (q_3, q_6)
(q_1, q_5) (q_4, q_7)
(q_1, q_6) (q_5, q_6)
(q_1, q_7) (q_7, q_8) 07
(q_1, q_8)

For q_0 q_2

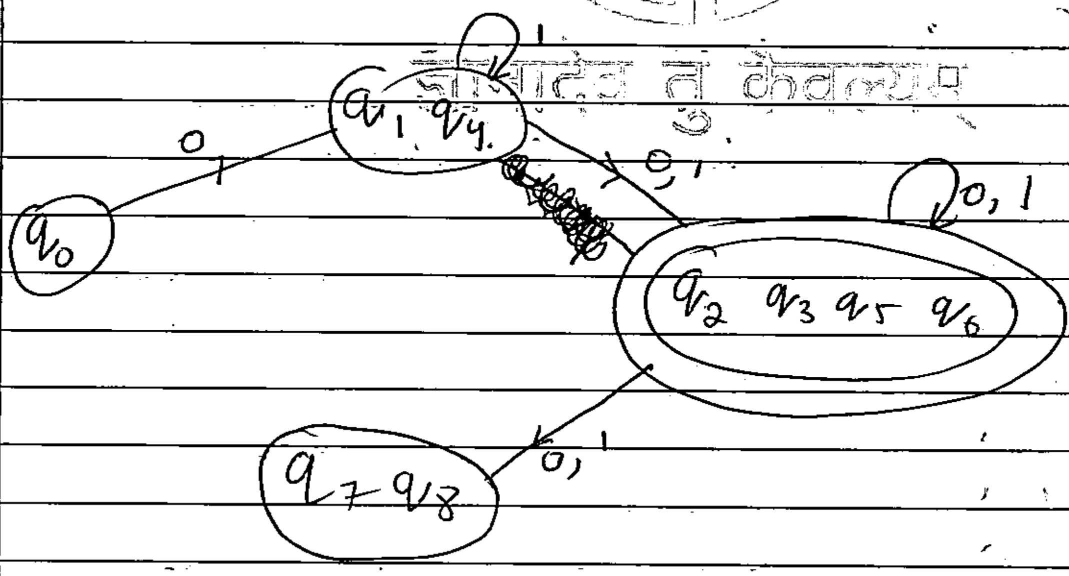
$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_2, 0) = q_7$ $\delta(q_2, \phi) = q_8$

For q_0 q_3

$\delta(q_0, 0) = q_1$ $\delta(q_0, 1) = q_4$
$\delta(q_3, 0) = q_8$ $\delta(q_3, 1) = q_7$

~~paired form~~
minimized form :-

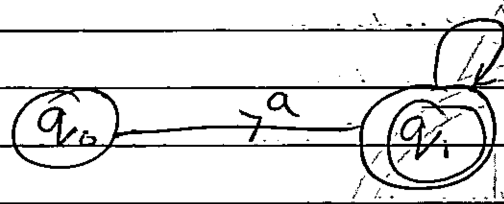
$\{q_0\}$ $\{q_1, q_4\}$ $\{q_2, q_3, q_5, q_6\}$ $\{q_7, q_8\}$



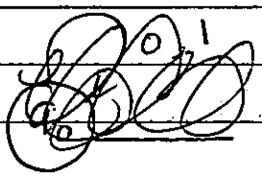
Q2a) ~~Q~~. closure property :-

$$a^+ = \{a, aa, aaa, aaa, aaaa - - - - - \}$$

closure property is the property of a regular grammer in which ϵ is not present it starts without ϵ.



~~Q2b~~)



Q2c) To prove the language is not regular we will use pumping lemma.

Pumping lemma :-

If A is a regular language with p pumping lemma such that string s, $|S| > p$ can be divided into 3 parts $s = xyz$ where y is not a null value should follow these condition :-

i) $|y| > 0$
ii) $|xy| \leq P$
iii) $xy^i z \in A$ where $i = 1, 2, 3$ —

According to question:
$a^n b^n$

Let pumping lemma be $P = 4$

$a^4 \quad b^4$

$S = \underbrace{a}_{x}\underbrace{a\,a\,a\;b\,b\,b}_{y}\underbrace{b}_{z}$

$x = a$
$y = aaabbb$
$z = b.$

condition i) $|y| > 0$
$6 > 0$ True

ii) $|xy| \leq P.$
$7 \leq 4$ True

iii) $xy^i z$

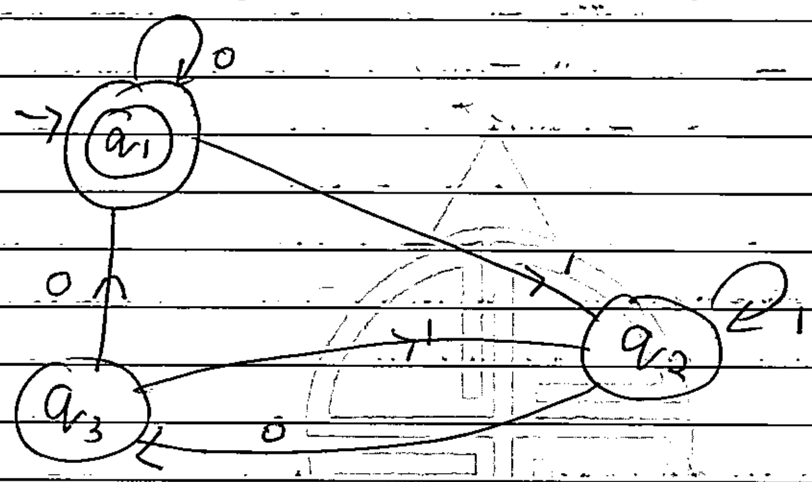
Let $i = 2$
then,
a, aaabbb aaabbb b
as it is not present in language thus it is
False

As ~~all~~ 3^{rd} condition does not ~~stasi~~ statisfy, thus ~~...~~

$L = \{a^n b^n \text{ where } n \geq 1\}$ is

not a regular language.

Q2d)



$$a_1 = \epsilon + q_1 \cdot 0 + q_3 \cdot 0$$
$$q_2 = q_2 \cdot 1 + q_3 \cdot 1 + q_1 \cdot 1$$
$$q_3 = q_2 \cdot 0$$

$$q_2 = q_2 \cdot 1 + q_3 \cdot 1 + q_1 \cdot 1$$
$$= q_2 \cdot 1 + q_2 \cdot 01 + q_1 \cdot 1$$
$$= q_2 (1 + 01) + q_1 \cdot 1 \qquad R = QP^*$$
$$= q_1 \cdot 1 \, (1+01)^*$$

$$q_3 = q_1 \cdot 1 \, (1 + 0.1)^* \, 0$$

$$q_1 = q_1 \cdot 0 + q_1 \cdot 1 (1+01)^* 0 \, 0 \qquad R = QP^*$$
$$= 0 + 1(1+01)^* 0 0^*$$

we have find the regular language using Arden's theorm ~~according~~ ~~to~~ ~~[illegible]~~ according to which if R & Q are ~~a~~ two language which is not null then

$$R = R + QP$$
$$= QP^*$$

Q3 a) ii) ~~[illegible]~~

$(1+0)^* 0\ 0$

$S \rightarrow A\ 0\ 0$

$A \Rightarrow 0 / 1 / \epsilon /$ ~~[illegible]~~ $/ A0 / A1 / 0A1 / 1A$

i) $S \Rightarrow A\ 1$

$A \Rightarrow 11 / 1111 / 1^{2n} / \epsilon$

Q3 b) Grammer are of 4 types :-
i) Type 0 ii) Type 1 iii) Type 2 iv) Type 3.

Grammer Type	Grammer accepted	Language Accepted	Automata
Type 0	Context Sensitive grammer	Recursively enumerable language	Turing machine
Type 1	Context Sensitive grammer	Recursive language.	Linearly bounded automata
Type 2	Context free grammer	Context free language	Push down automata
Type 3	Regular grammer	Regular language	FSA

Q3 d) $S \to 0B \mid 1A$

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

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

i) $w = 00110101$

$S \to 0B$ $\quad B = 0BB$

$S \to 0\,0BB$ $\quad B = 1S$

$S \to 001SB$ $\quad S = 1A$

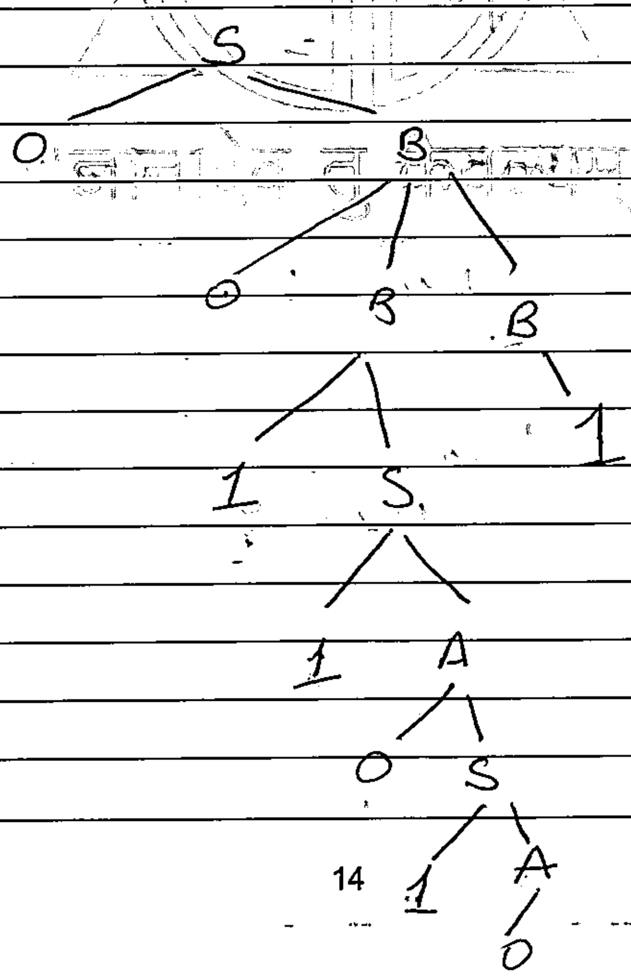
$S \to 0011AB$ $\quad A = 0S$

$S \to 00110SB$ $\quad S = 1A$

$S \Rightarrow 001101AB$ $\quad A = 0$

$S \Rightarrow 0011010B$ $\quad B = 1$

$S \Rightarrow 00110101$



Let ~~B~~ $w = 100011$

LMD =>

$S \to 1A$ $\quad A = 0S$

$S \to 10S$ $\quad S = 0B$

$S \to 100B$ $\quad B = 0BB$

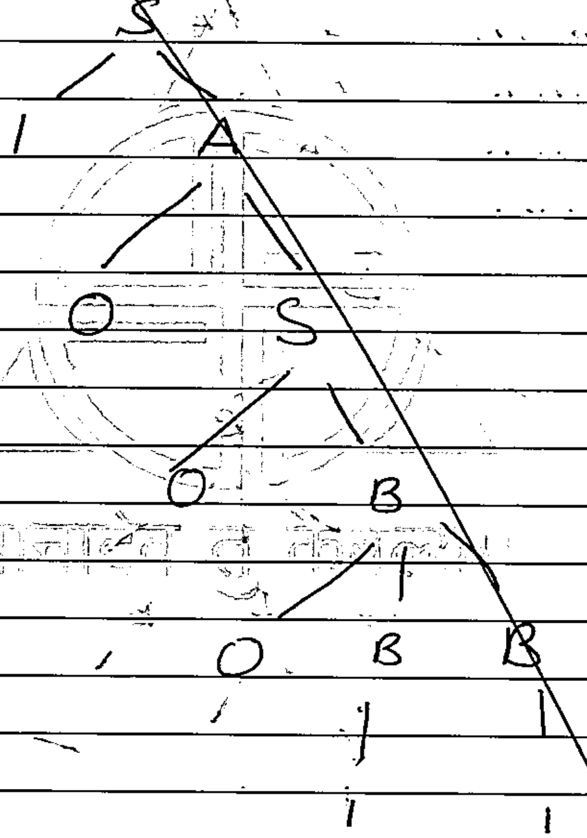
$S \to 1000BB$ $\quad B \Rightarrow 1S$

$S \to 10001SB$ $\quad$ ~~Btb~~ $S \Rightarrow 1A$

$S \to 100011AB$ $\quad A = 0$

$S \Rightarrow 10001110B$ $\quad B = 1$

$S \Rightarrow 10001110$



ii) For LMD & RMD

Let $w = 00110101$.

LMD :- Calculation from left side.

$S \rightarrow 0B$ $B = 0BB$

$S \rightarrow 00BB$ $B = 1S$

$S \rightarrow 001SB$ $S = 1A$

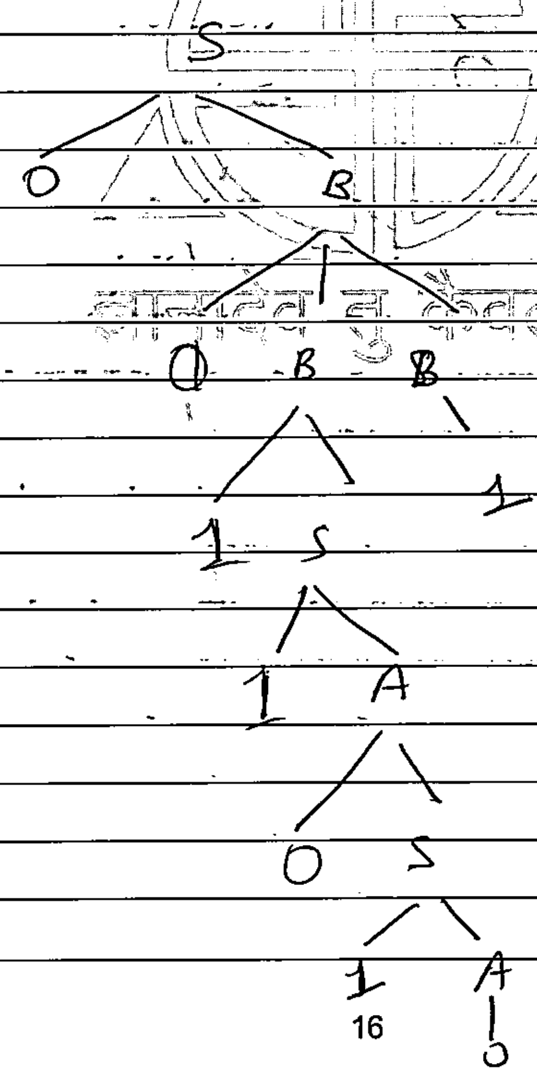
$S \rightarrow 0011AB$ $A = 0S$

$S \rightarrow 00110SB$ $S = 1A$

$S \rightarrow 001101AB$ $A = 0$

$S \rightarrow 0011010B$ $B = 1$

$S \rightarrow 00110101$



RMD. ⇒ Calculation from Right side.

$S \to 0B \qquad B = 0BB$

$S \Rightarrow 00BB \qquad B = 1$

$S \Rightarrow 00B1 \qquad B \Rightarrow 1S$

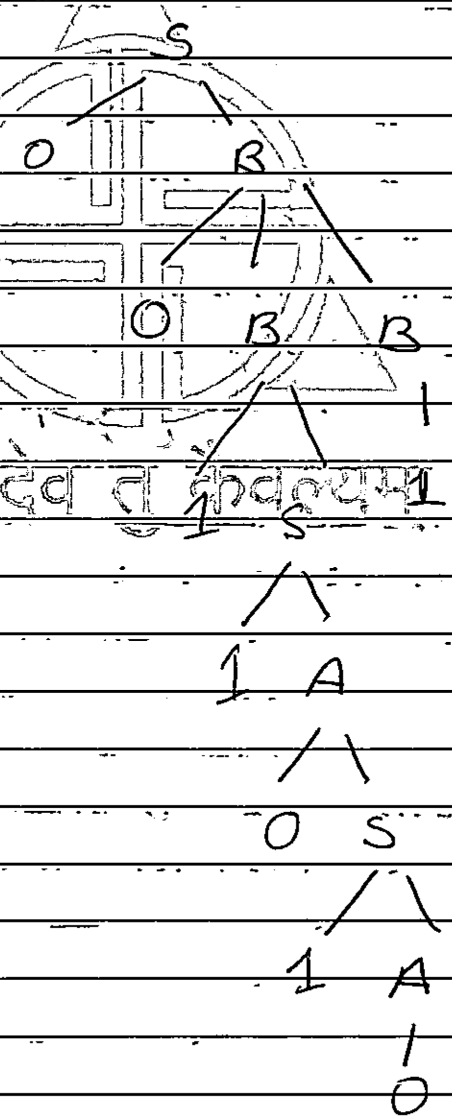
$S \Rightarrow 001S1 \qquad S \Rightarrow 1A$

$S \Rightarrow 0011A1 \qquad A \Rightarrow 0S$

$S \Rightarrow 00110S1 \qquad S \Rightarrow 1A$

$S \Rightarrow 001101A1 \qquad A = 0$

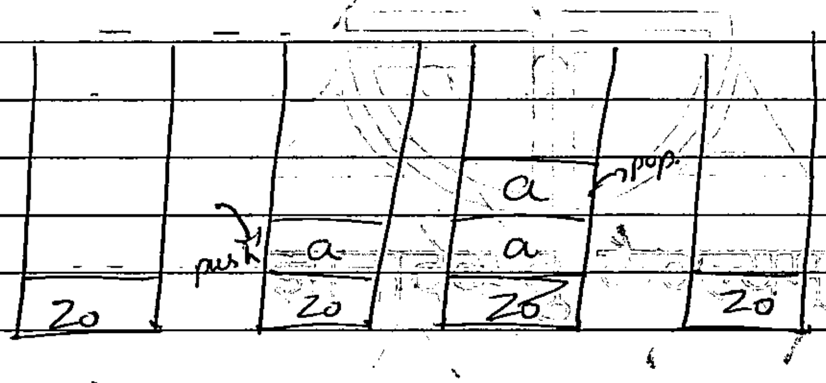
$S \Rightarrow 00110101$

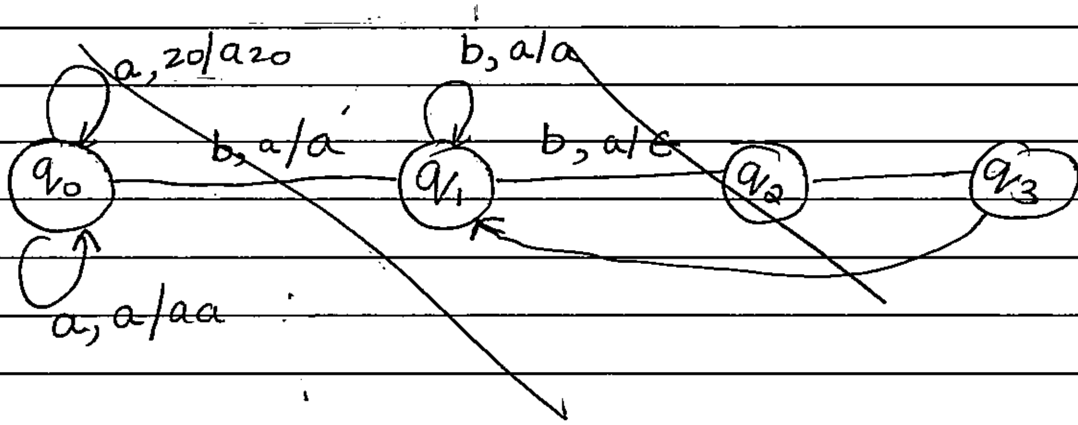


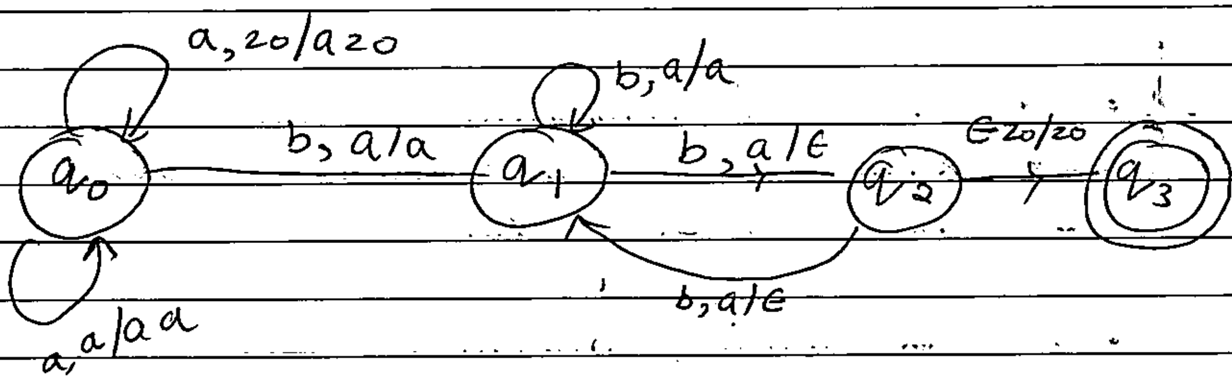
Q4a)	NPDA	DPDA
i)	It is non-deterministic pushdown automat	i) It is deterministic push down automata

Q4b ~~qeDro~~ $a^n b^{2n}$

a a a b b b b







$\delta(q_0, a\, z_0) = (q_0, a z_0)$
$\delta(q_0, a\, a) = (q_0, aa)$
$\delta(q_0, b\, a) = (q_1, a)$
$\delta(q_1, b\, a) = (q_1, a)$
$\delta(q_1, b\, a) = (q_2, \in)$
$\delta(q_2, b\, a) = (q_1, \in)$
$\delta(q_2, \in z_0) = (q_3, z_0)$

Q4d) 2) Halting problem of Turing machine :-

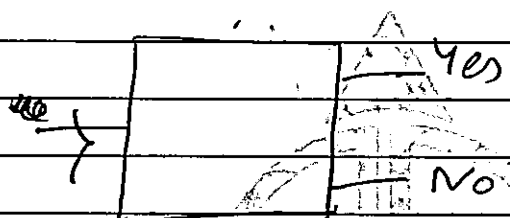
Halting problem is undecidable it is not a problem, but it will ask a question.

eg :- Consider a string w

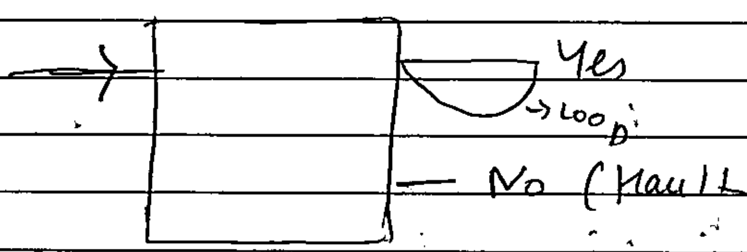
will the turning machine will complete string w in finite amout of step

- If turning machine complete the string w in finite amount of time then 'yes'

- If ~~th~~ turning machine ~~can~~ does not complete the string w in finite amount of time the 'No'



- If turning machine complete the string w in finite amount of time then
  - → loop for ever
  - ⇒ otherwise hault.



(3) Post correspondence problem :-

In Post correspondence problem we make same string in numerator and denominator.

eg. :-

	a	b		
x	1	111	$\frac{1}{111}$	— 1
y	10111	10	$\frac{10111}{10}$	— 2
z	10	0	$\frac{10}{0}$	— 3

$$\Rightarrow \overset{2}{\frac{10111}{10}} \cdot \overset{1}{\frac{1}{111}} \cdot \overset{1}{\frac{1}{111}} \cdot \overset{3}{\frac{10}{0}}$$

Q5a) partial function :-

Let f be the function such that $f: x \rightarrow y$ defined for some value of x then it is a partial function.

eg → i) f $N \rightarrow N$
$x \rightarrow x/2$
is a partial function.

ii) f $R \rightarrow R$
$\sqrt{x}$ is a partial function.

~~Initial function :-~~

~~i) zero function ⇒ defined as $Z(x) = 0$~~

~~ii) sussive function ⇒ defined as $S(x) = x+1$~~

Initial junction :-

i) zero junction -
defined as $z(x) = 0$

eg i) $z(8) = 0$
ii) $z(9) = 0$.

ii) ~~[illegible]~~ sussceesive junction -
defined as $S(x) = x+1$

eg i) $S(10) = 11$
ii) $S(21) = 22$

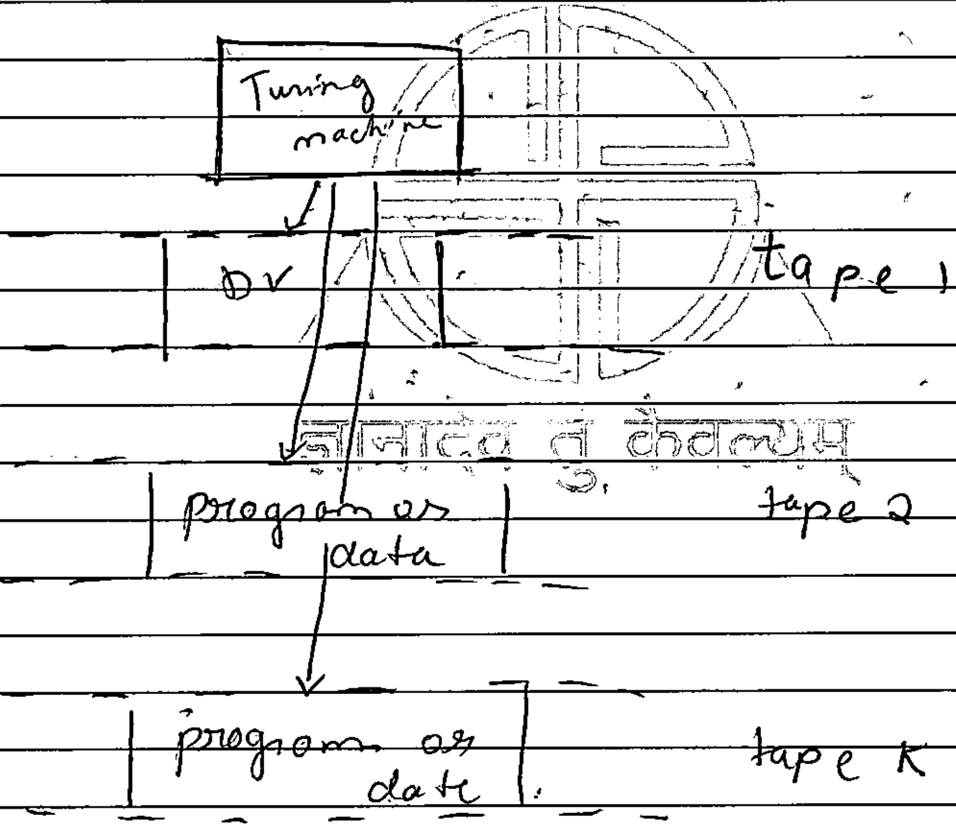
iii) Pojection function -
defined as $U_i^n(1, 2, 3 \cdots n)$

eg i) $U_3^3(\cancel{8}\ 1, 4, 6) = 6$
ii) $U_2^2(2, 6) = 6$.

Q 5c) Computabity complexity.

Time complexity — Space complexity.

Consider a turing machine with K no. of tapes



i) consider a turning machine with K no. of tapes

ii) Turning machine will take time to complete each steps n & i.e

$$T(n) = O(n)$$

ii) Turning machine will scan n steps in

$$S(n) = O(n)$$

Q 5b) i) $f(x, y) = x * y$ {+ is primitive recursive function} {proved at last.}

$$f(x, 0) = x \cdot 0$$
$$= 0$$
$$= g(x)$$
$$= z(x)$$

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

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

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

It is a primitive recusive function.
+ is a proved primitive recursive function.

ii) $f(x,y) = x^y$ {* is a primitive recursive function}

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

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

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

$\therefore f(x,y,z) = U_3^3(x,y,z) * U_1^3(x,y,z)$

Thus, $f(x,y) = x^y$ is also a primitive recursive function

iii) prove of + is primitive recursive function.

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

$f(x,0) = x$
$g(x)$
$U_1^1(x)$

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

$$f(x, y, f(x, y)) = S\left(U_3^3\, f(x, y, z)\right)$$
$$f(x, y, z) = S\left(U_3^3(x, y, z)\right)$$

Thus

ज्ञानादेव तु कैवल्यम्

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