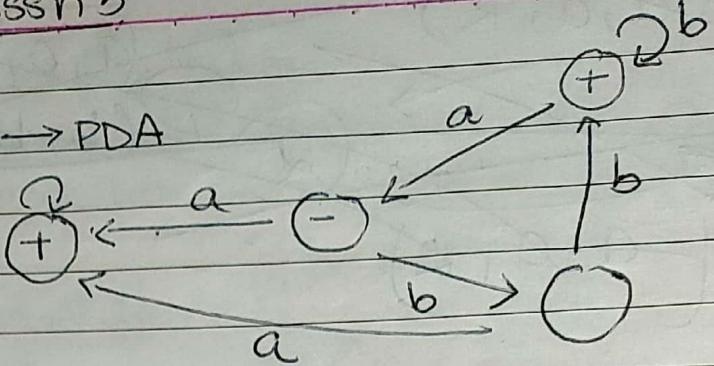
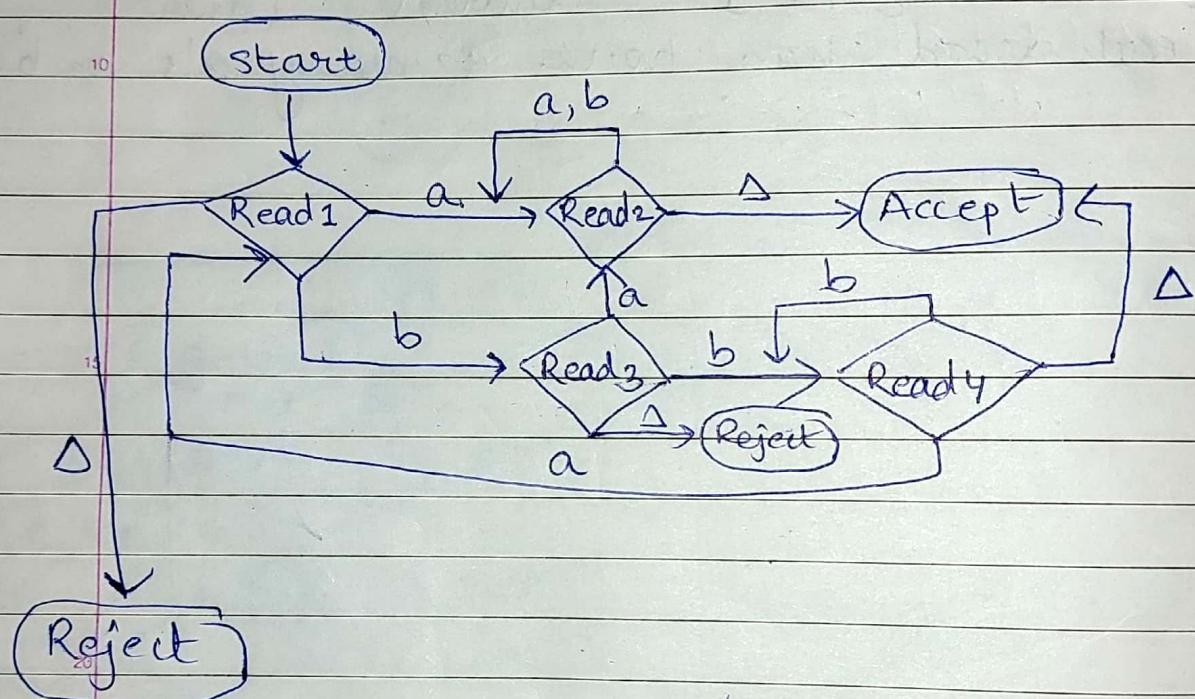
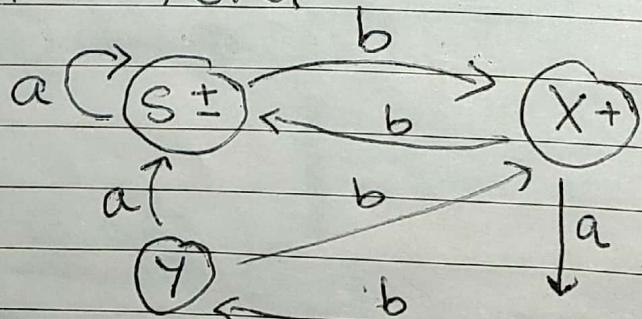


Assn 31)  $FA \rightarrow PDA$  $a, b$ PDA2)  $FA \rightarrow CFG$ CFG:

$$S \rightarrow aS \mid bX \mid \Lambda$$

$$X \rightarrow az \mid bS \mid \Lambda$$

$$z \rightarrow az \mid by$$

$$y \rightarrow aS \mid bx$$

37 Eliminate N-reductions for the CFG.

$$S \rightarrow axbx$$

$$X \rightarrow aY|bY|\lambda$$

$$Y \rightarrow X|ZY|b$$

$$Z \rightarrow XY|c$$

$X \rightarrow \lambda$ ,  $X$  is nullable.

$$\begin{aligned} S \rightarrow axbx &\Rightarrow S \rightarrow axb|abx|ab|axbx \\ X \rightarrow aY|bY|\lambda &\Rightarrow X \rightarrow aY|bY \\ Y \rightarrow X|ZY|b &\Rightarrow Y \rightarrow \lambda|ZY|b|X \\ Z \rightarrow XY|c &\Rightarrow Z \rightarrow XY|Y|c \end{aligned}$$

$Y \rightarrow \lambda$ ,  $Y$  is nullable

$$\begin{aligned} S \rightarrow axbx | axb | abx | ab \\ X \rightarrow aY|bY|\lambda|b &\Rightarrow X \rightarrow aY|bY \\ Y \rightarrow ZY|b|X|\lambda &\Rightarrow Y \rightarrow X|ZY|b|Z \\ Z \rightarrow XY|Y|c &\Rightarrow Z \rightarrow XY|X|Y|c|\lambda \end{aligned}$$

$Z \rightarrow \lambda$ ,  $Z$  is nullable.

$$\begin{aligned} S \rightarrow axbx | axb | abx | ab \\ X \rightarrow aY|bY|\lambda|b &\Rightarrow X \rightarrow aY|bY \\ Y \rightarrow X|ZY|b|Z &\Rightarrow Y \rightarrow X|Y|Z|ZY|b \\ Z \rightarrow XY|X|Y|c|\lambda &\Rightarrow Z \rightarrow XY|X|Y|c \end{aligned}$$

∴ Final answer =

$$S \rightarrow axbx | axb | abx | ab$$

$$X \rightarrow aY|bY|\lambda|b$$

$$Y \rightarrow X|Y|Z|ZY|b$$

$$Z \rightarrow XY|X|Y|c$$

4) CFG  $\rightarrow$  CNF

$$S \rightarrow ABC$$

$$A \rightarrow aAS | a | \lambda$$

$$B \rightarrow sbS | A | bb$$

$$C \rightarrow b$$

①  $A \rightarrow \lambda, B \rightarrow A$ , A and B nullable

$$S \rightarrow ABC \Rightarrow S \rightarrow ABC | BC | AC | C$$

$$A \rightarrow aAS | a | \lambda \Rightarrow A \rightarrow aS | a | aAS$$

$$B \rightarrow sbS | A | bb \Rightarrow B \rightarrow sbS | A | bb | \lambda$$

$$\Rightarrow B \rightarrow sbS | A | bb$$

$$c \rightarrow b$$

② Introduce  $X \rightarrow a$ , with already  $C \rightarrow b$

$$S \rightarrow ABC | BC | AC | C$$

$$A \rightarrow XAS | X | XS$$

$$B \rightarrow SCS | A | CC$$

$$C \rightarrow b$$

$$X \rightarrow a$$

③ Remove unit productions

$$S \rightarrow ABC | BC | AC | b$$

$$A \rightarrow XAS | XS | a$$

$$B \rightarrow SCS | A | CC$$

$$X \rightarrow a$$

$$C \rightarrow b$$

④ CNF:

$$S \rightarrow RC | BC | AC | b$$

$$A \rightarrow RS | XS | a$$

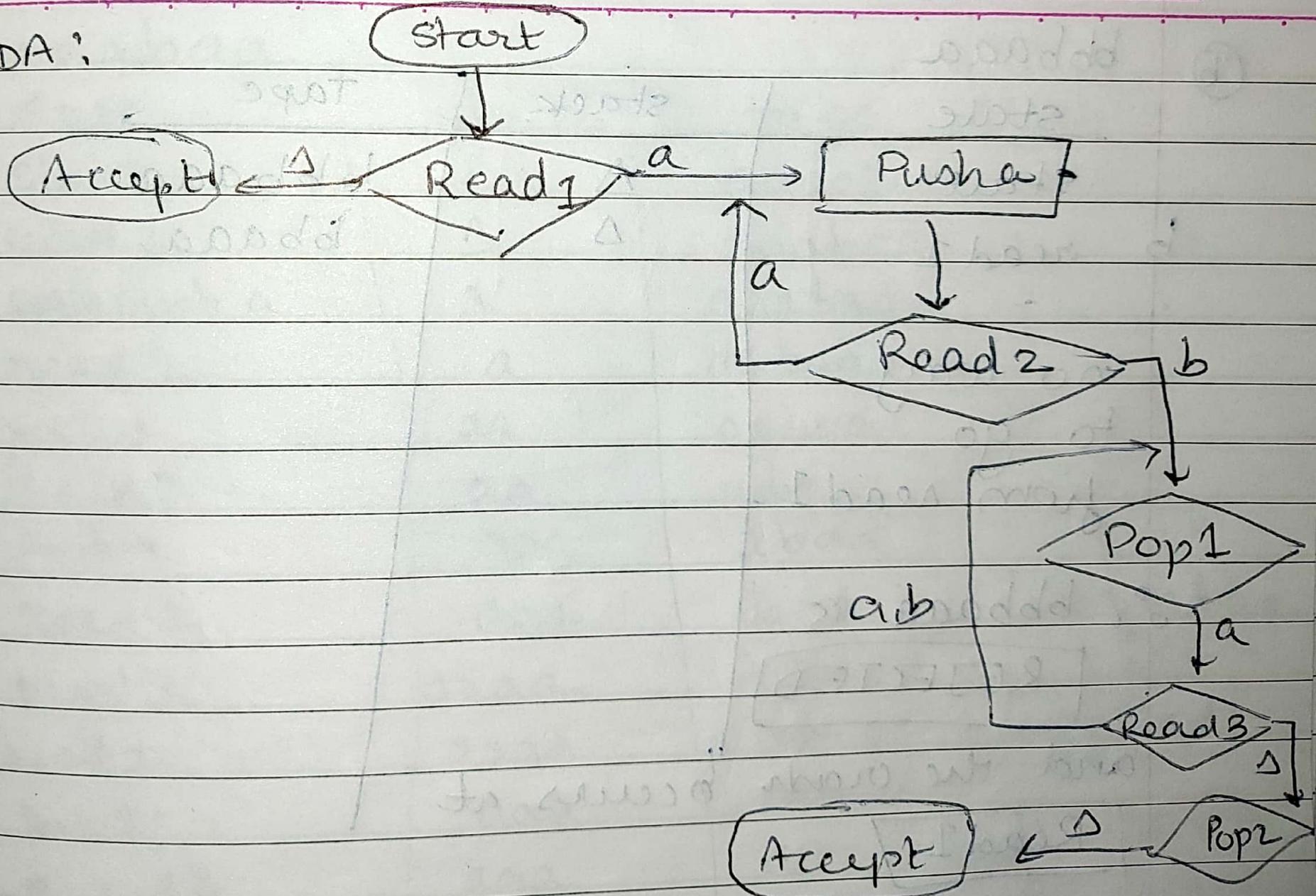
$$B \rightarrow TS | A | CC$$

$$R \rightarrow AB$$

$$Q \rightarrow XA$$

$$T \rightarrow SC$$

5) PDA :



Q5

@ aaabbb

<u>state</u>	<u>stack</u>	<u>tape</u>
start	Δ	aaabbb
a read 1	Δ	aabb
- push a	a	aabb
a read 2	a	abb
- push a	aa	abb
a read 2	aa	bbb
- push a	aaa	bbb
b read 2	aaa	b
a pop 1	aa	b
b a read 3	aa	b
a pop 1	a	b b
b read 3	a	△
a pop 1	Δ	△
read 3	Δ	△
pop 2	Δ	△
accept	Δ	△

∴ aaabbb is ACCEPTED.

(6) bbbaaa

state	stack	Tape
start	Δ	bbbaaa
b read 1	Δ	bbaaa
no way to go from read 1		
b. bbbaaa is REJECTED		

and the crash occurs at Read 1 because there is no path for the machine when 'b' is read input in Read 1.

(7) aaabbbaa

state	stack	Tape
start	Δ	aaabbbaa
a read 1	Δ	aabbbaa
push a	a	aabbbaa
a read 2	a	abbaa
push a	aa	abbaa
a read 2	aa	abbaa
push a	aaa	abbaa
b read 2	aaa	baa
pop 1	aa	baa
b read 3	aa	aa
pop 1	a	aa
a read 3	a	a
pop 1	Δ	a
a read 3	Δ	Δ
pop 1	Δ	Δ

Rejected

it crashes at pop 1

because there is no way at pop 1 when 'Δ' is popped

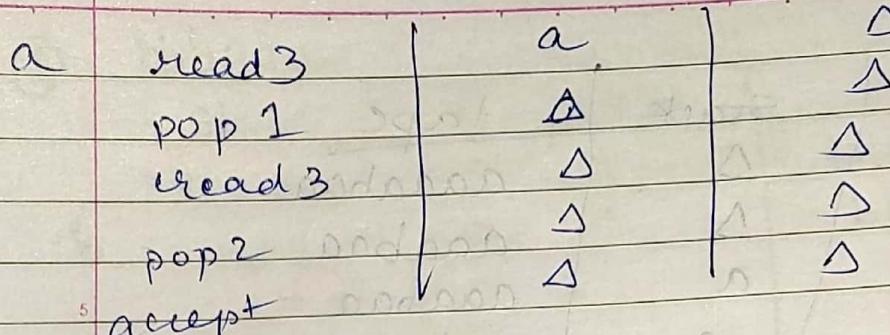
	stack	tape
a start	Δ	aaaabaa
a read 1	Δ	aaabaa
a push a	a	aaabaa
a head 2	a	aabaa
a push a	aa	aabaa
a read 2	aa	abaa
a push a	aaa	abaa
a read 2	aaa	baa
a push a	aaaa	baa
b read 2	aaaa	aa
pop 1	aaa	aa
a head 3	aa	a
pop 1	aa	a
a read 3	aa	Δ
pop 1	a	Δ
read 3	a	Δ
pop 2	Δaa	Δ
a		Δ

is  
Rejected

it crashes at pop 2 - because there is no path, when 'a' is popped at pop 2?

@aaabaa

	stack	tape
a start	Δ	aaabaa
a read 1	Δ	aabaa
a push a	a	aabaa
a read 2	a	abaa
a push a	aa	abaa
a read 2	aa	baa
b read 2	aa	baa
pop 1	aa	aa
a read 3	aa	a
pop 1	a	a



∴ aaabaaa is ACCEPTED

$$\text{Q6} \quad L = b(a^*b + a)^*$$

CFG for b

$$S_1 \rightarrow b$$

CFG for a

$$S_2 \rightarrow a$$

CFG for  $a^*$

$$S_3 \rightarrow S_2 S_3 \mid \lambda$$

CFG for  $a^*b$

$$S_4 \rightarrow S_3 S_1$$

CFG for  $a^*b + a$

$$S_5 \rightarrow S_4 S_6 \mid S_6 S_4 \mid S_2$$

ERLG for  $b(a^*b + a)^*$

∴ CFG for  $b(a^*b + a)^*$

CFG for  $(a^*b + a)^*$

$$S_6 \rightarrow S_5 S_6 \mid \lambda$$

$$S \rightarrow S_1 S_6$$

$$S_6 \rightarrow S_5 S_6 \mid \lambda$$

$$S_5 \rightarrow S_4 S_2$$

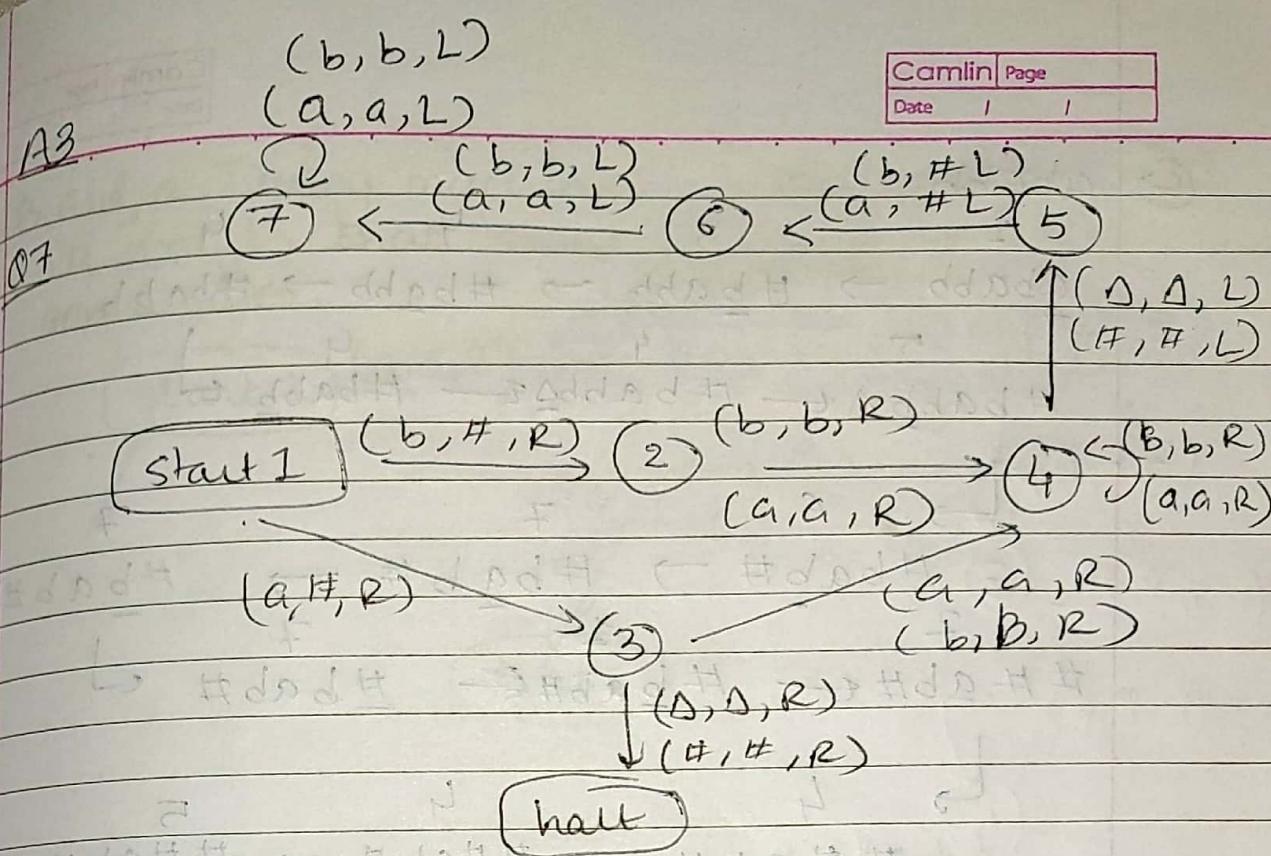
$$S_4 \rightarrow S_3 S_1$$

$$S_3 \rightarrow S_2 S_3 \mid \lambda$$

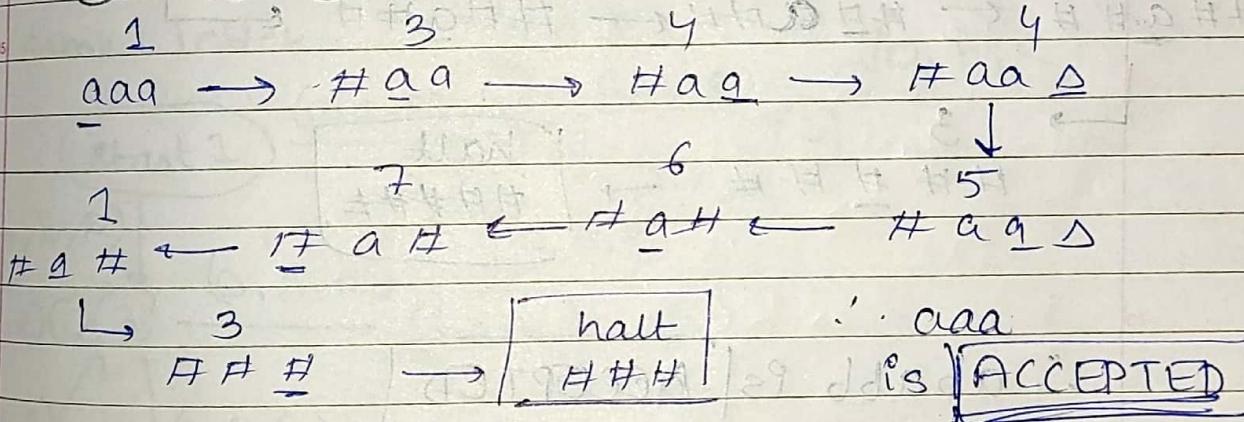
$$S_2 \rightarrow a$$

$$S_1 \rightarrow b$$

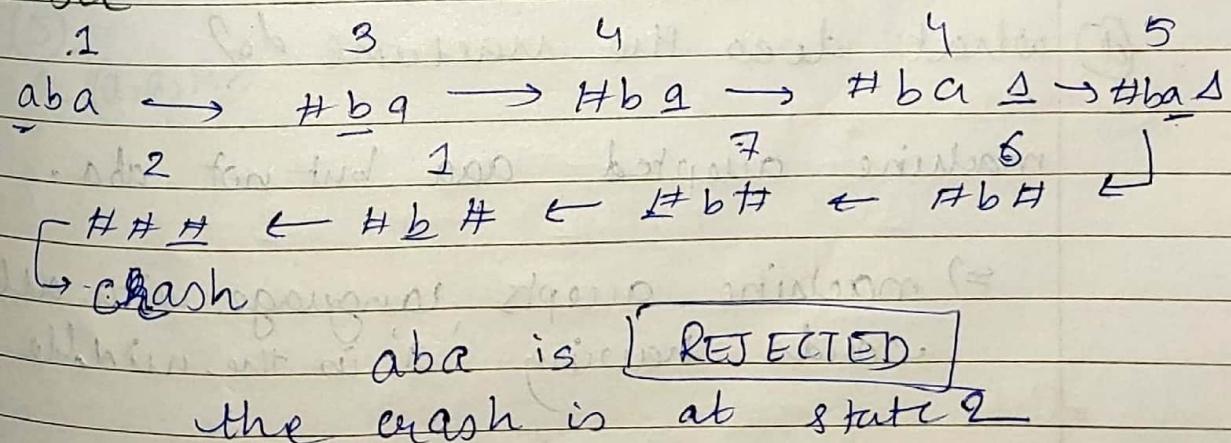
Q7



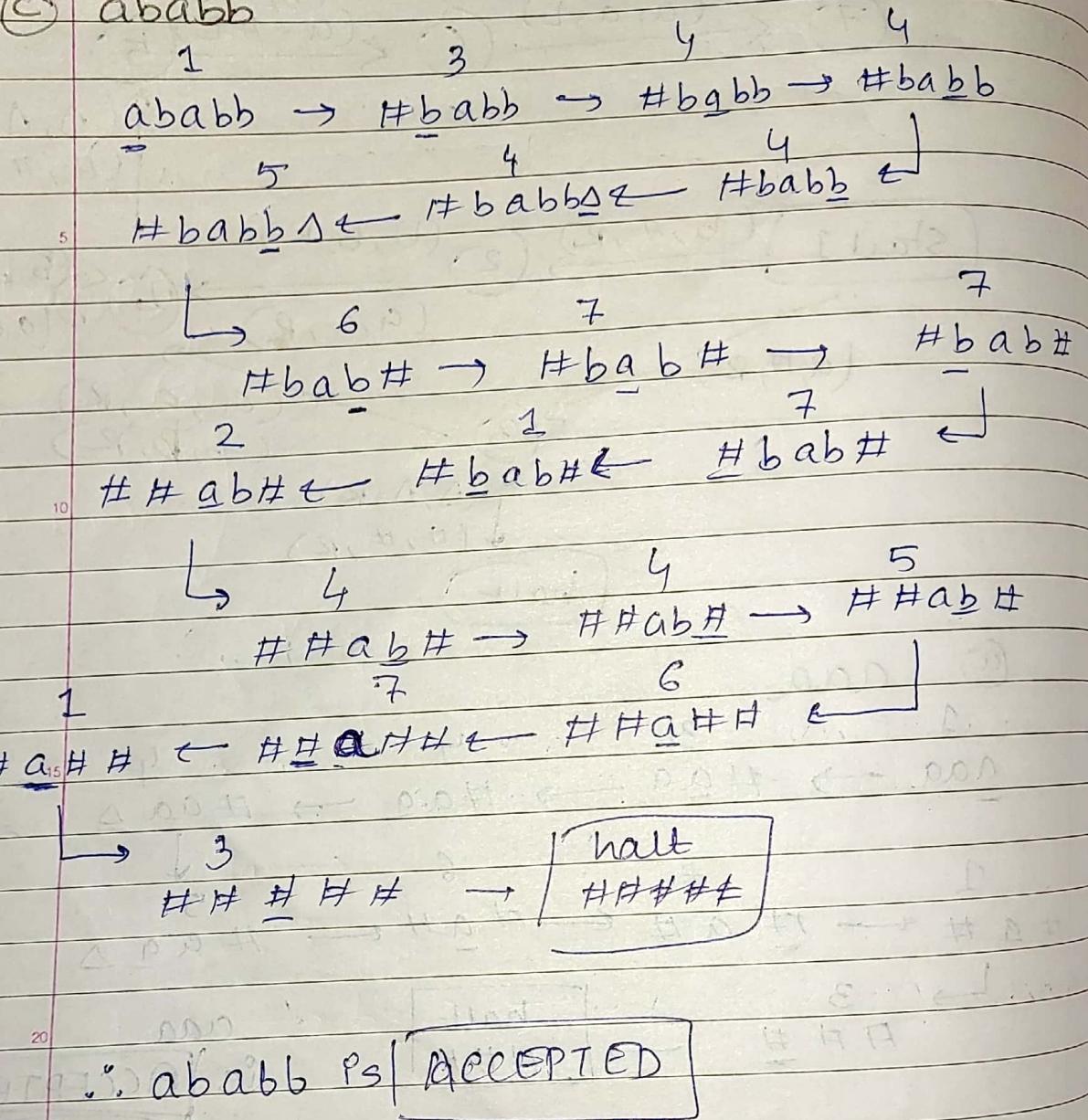
@) aaa



@) aba



(c) ababb

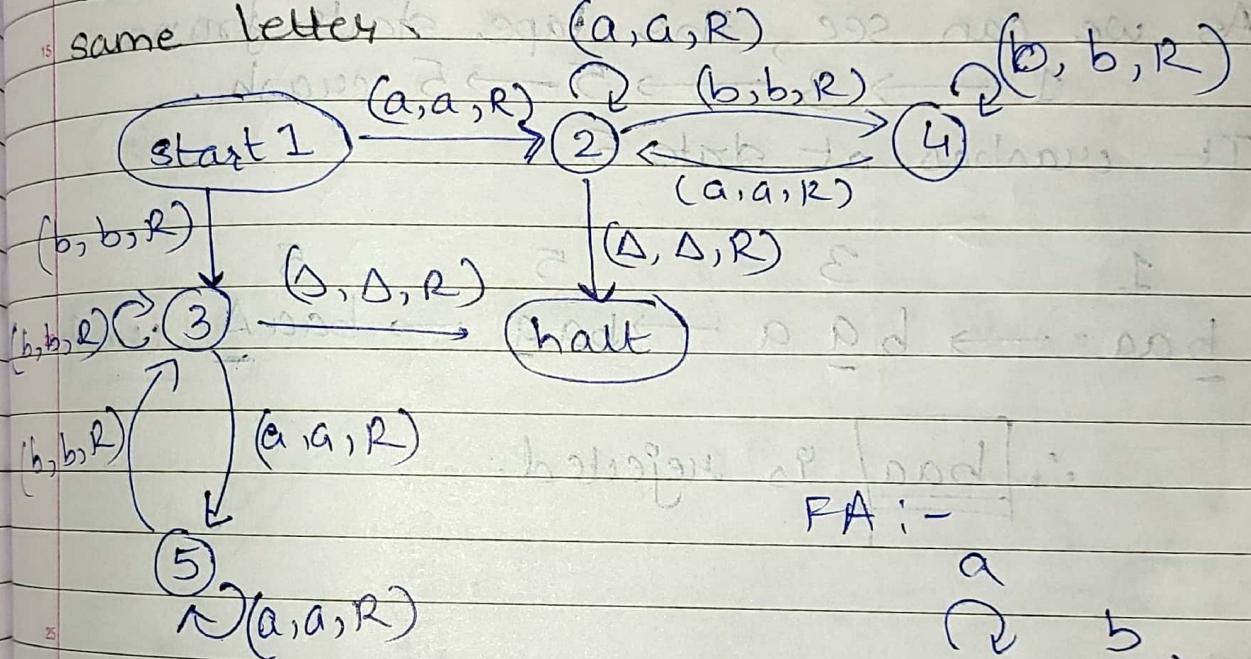


(d) what does the machine do?

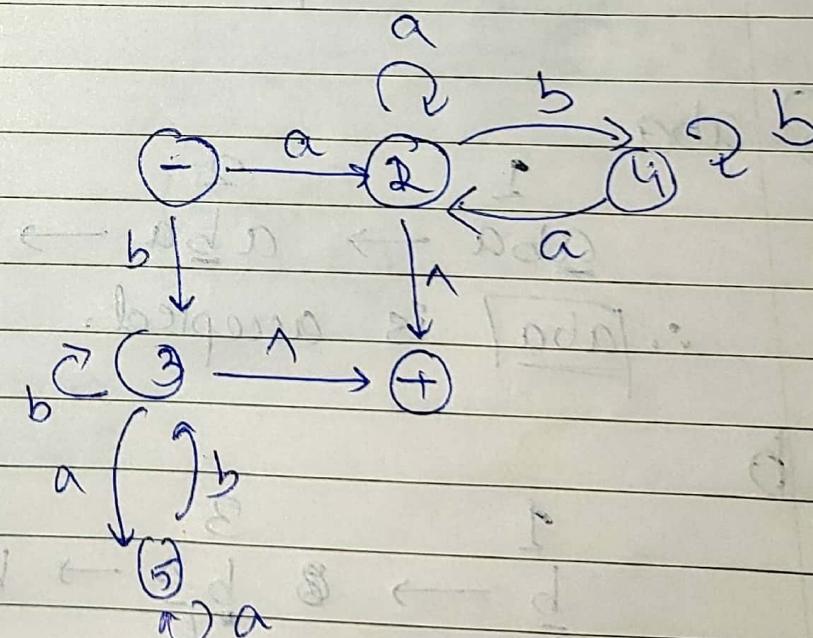
machine accepted aaa but not aba.

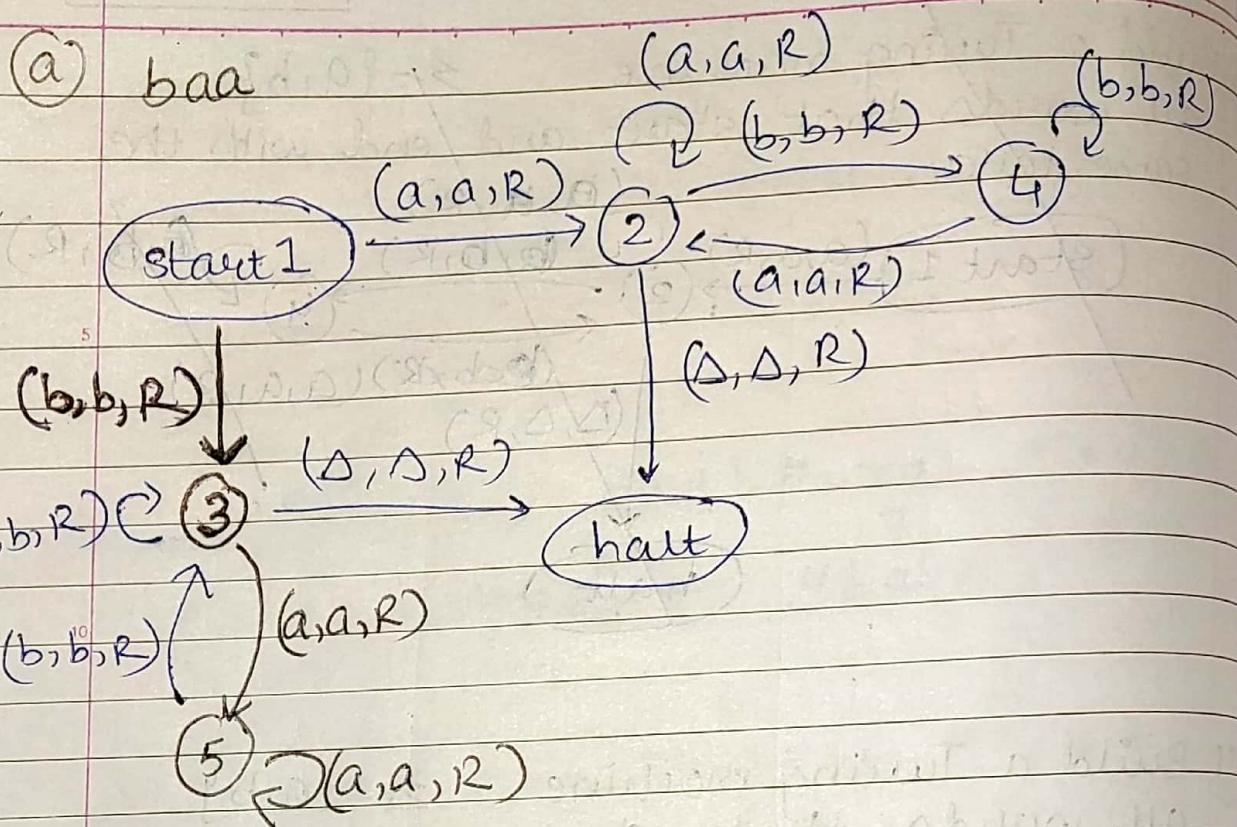
⇒ machine accepts language with all words having 'a' in the middle.

Q8 Build a Turing machine  $\Sigma = \{a, b\}$   
 all words that start and end with the  
 same letter



PA :-





As we can see, the tape starts from  
 $1 \rightarrow 3 \rightarrow 5 \rightarrow 5$ , crash.  
 It crashes at state 5.

1            3            5            5  
baa  $\rightarrow$  ba a  $\rightarrow$  baa  $\rightarrow$  baa Δ crash  
 $\therefore \boxed{\text{baa}}$  is rejected.

(b) aba

1            2            4            2  
aba  $\rightarrow$  aba  $\rightarrow$  aba  $\rightarrow$  aba Δ  $\rightarrow$  halt.  
 $\therefore \boxed{\text{aba}}$  is accepted.

(c) b

1            3            halt  
b  $\rightarrow$  b Δ  $\rightarrow$  b SS  
 $\therefore \boxed{b}$  is accepted.

Q9. Build a TM  $\Sigma = \{a, b\}$ ; language Double A each word has twice as many a's as b's.  
[Insert # routine] -

