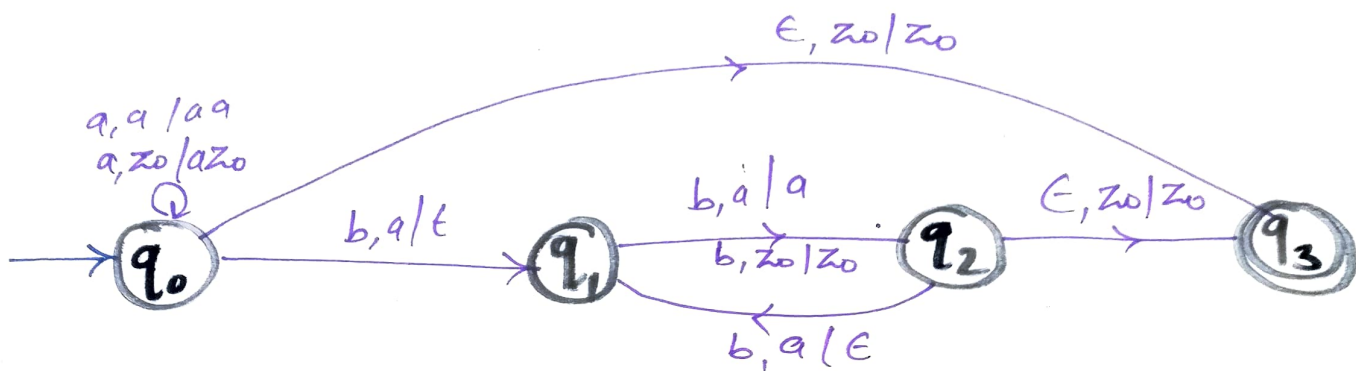
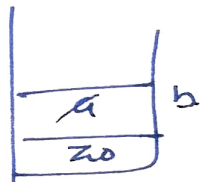


$$4x \quad L = \{a^m b^n \mid n = 2m\}$$

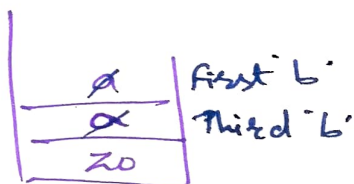
$$\rightarrow L = \{ \epsilon, \underline{a} \underline{b} \underline{b}, \underline{a} \underline{a} \underline{b} \underline{b} \underline{b} \dots \}$$



$W = a b b$
 Push ↓ Pop ↓ No opn



$W = a a b b b b$
 Push ↓ Pop ↓ No opn ↓ Pop
 No opn



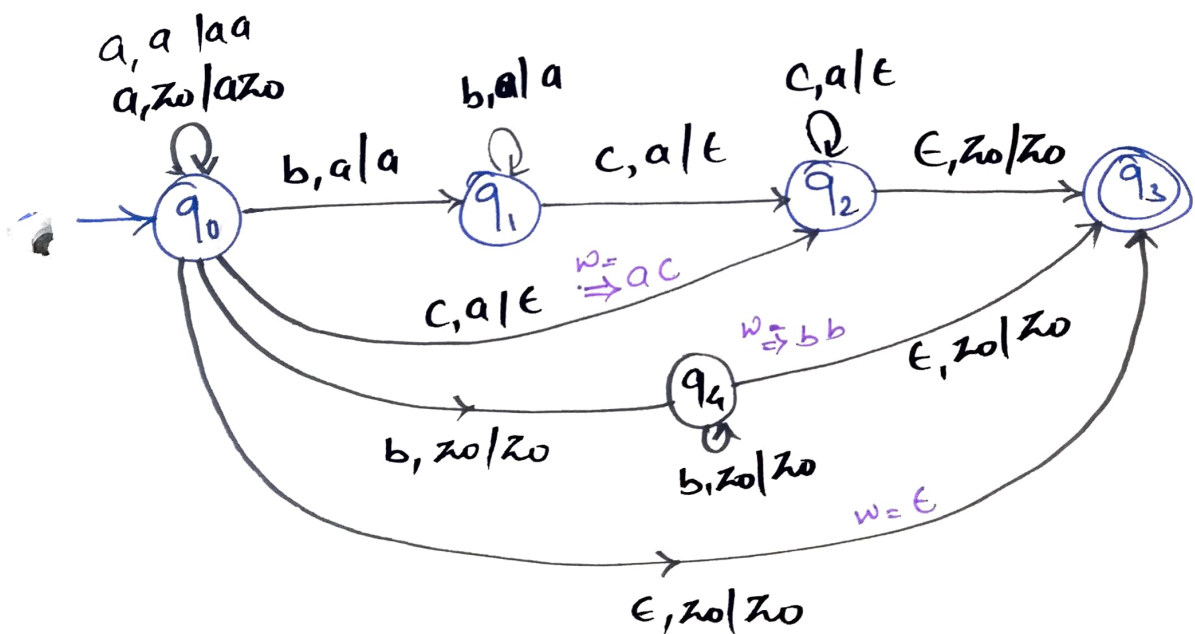
Q. Construct the PDA for the following ~~RRR~~ language.

① $L = \{a^n b^m c^n \mid m, n \geq 0\}$ CFL

→ $L = \{\epsilon, abc, aabbcc, aabcc, aaabbccc, \dots, bb, \dots, ac, \dots\}$

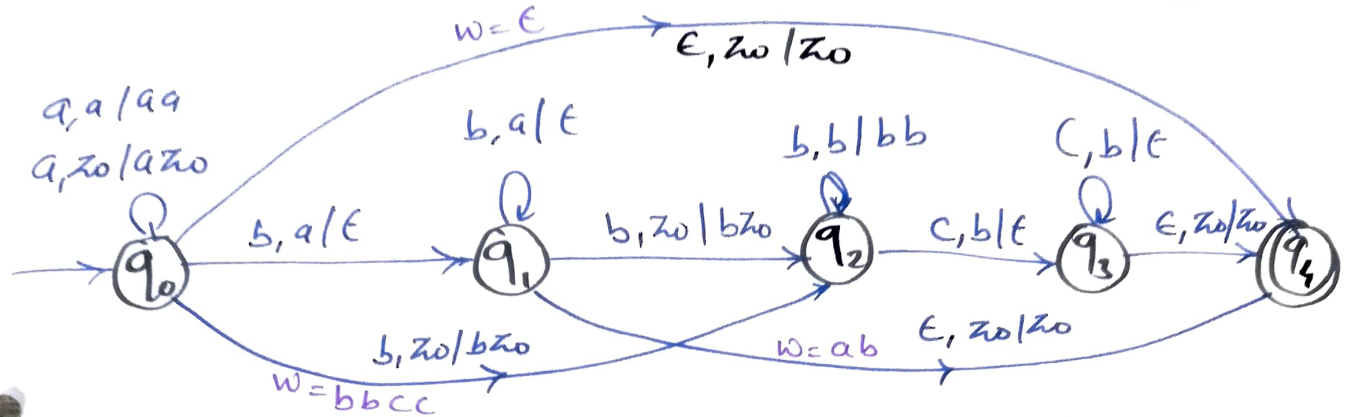
Noopⁿ
 a^n \downarrow Push
 b^m \downarrow Noopⁿ
 c^n \uparrow Pop

$a^n b^m c^n \Rightarrow m=0, n=0$
 ϵ
abc $\Rightarrow m=1, n=1$
ac $\Rightarrow m=0, n=1$
bb $\Rightarrow m=2, n=0$



② $L = \{ a^n b^m c^p \mid m = n + p \}$

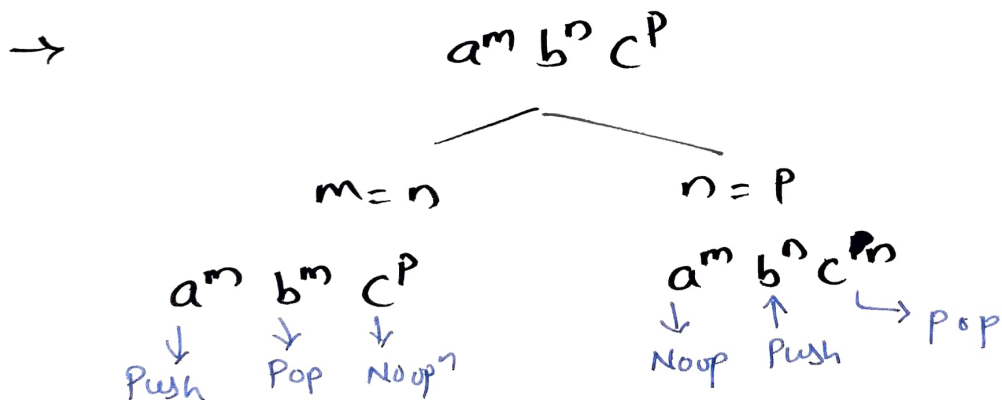
→ $L = \{ \epsilon, a b b c, a a b b b b c c, \dots \}$



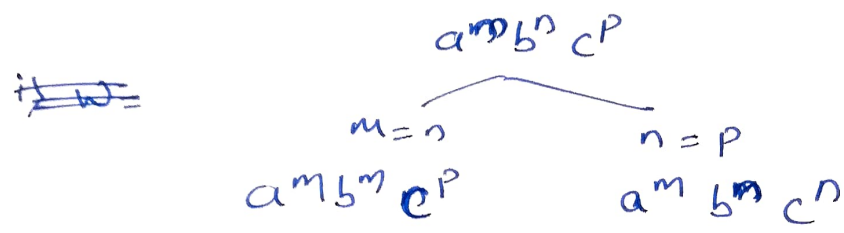
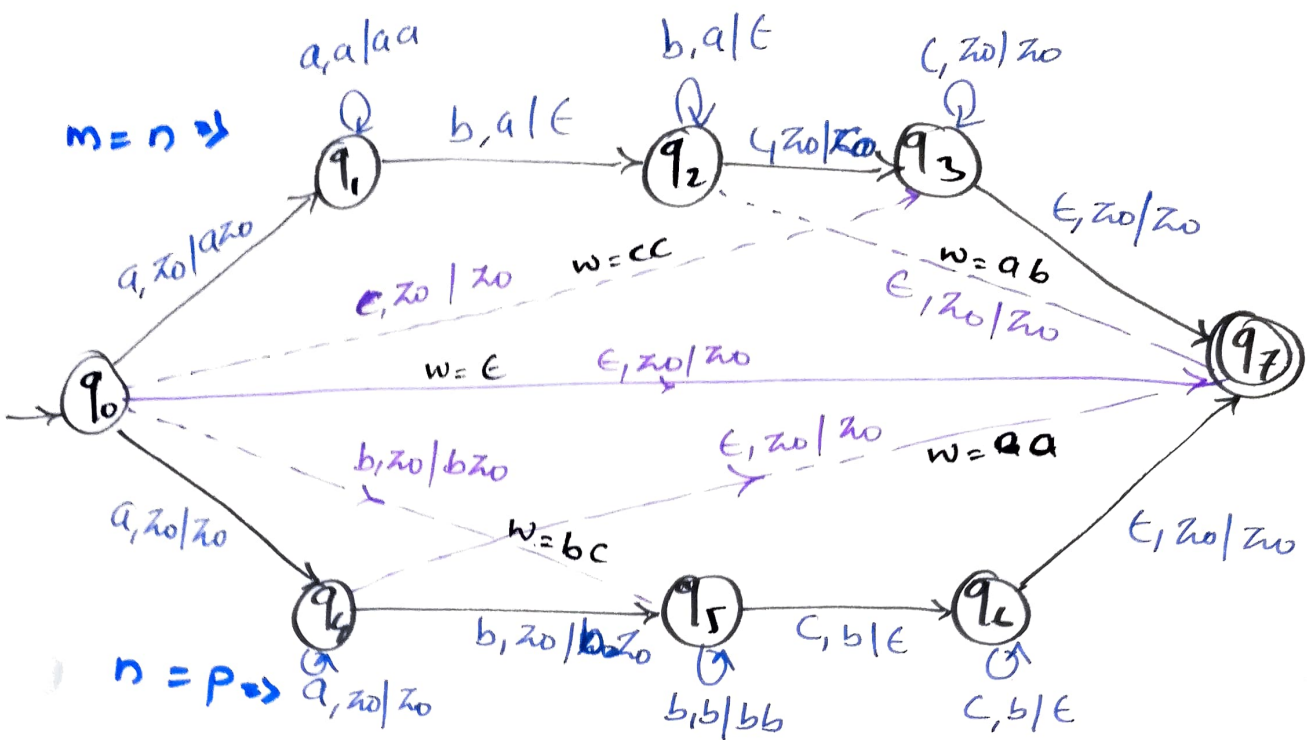
$w = \epsilon, q_0 \rightarrow q_4$
 $a^1 b^{1+0} c^0, w = a b \epsilon, q_0 \rightarrow q_1 \rightarrow q_4$
 $a^0 b^{0+2} c^2, w = b b c c, q_0 \rightarrow q_2 \rightarrow q_3 \rightarrow q_4$
 $a^2 b^{2+1} c^1, w = \underline{a a} \underline{b b b} c, \text{Push Pop push Pop}$

a	for b	b	for c
a	for b	b	for c
z_0		z_0	

③ $L = \{ a^m b^n c^p \mid m = n \mid n = p \}$



$\delta(q_0, a, z_0) \rightarrow a z_0 \Rightarrow \text{Push}$
 $\delta(q_0, a, z_0) \rightarrow z_0 \Rightarrow \text{No op?}$



- i) $m = 0 \Rightarrow c^p \Rightarrow cc \Rightarrow \underline{q_0 \rightarrow q_3}$
- ii) $p = 0 \Rightarrow a^m b^m \Rightarrow aabb \Rightarrow \underline{q_2 \rightarrow q_7}$
- i) $m = 0 \Rightarrow a^m \Rightarrow \underline{q_4 \rightarrow q_7}$
- ii) $m = 0 \Rightarrow b^n c^n \Rightarrow \underline{q_0 \rightarrow q_5}$

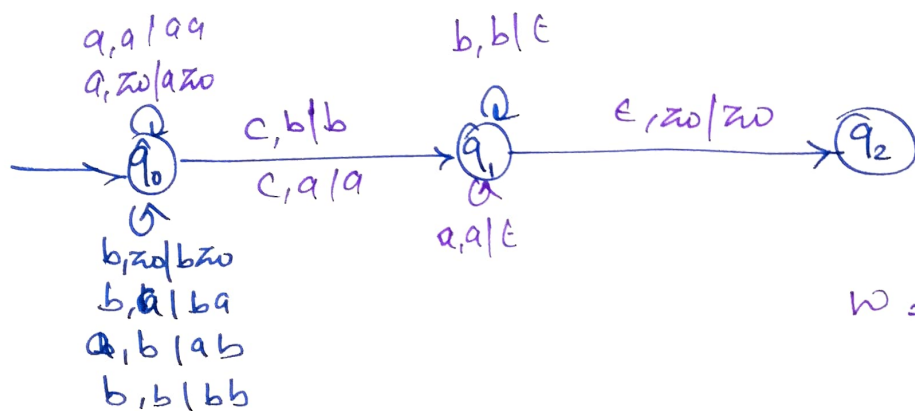
Q Construct PDA for given palindrome.

① $L = \{ w c w^R \mid w \in (a, b)^+ \}$ odd length Palindrome.

\Rightarrow $w c w^R$
 Original String \leftarrow \rightarrow Reverse String

ab c ba
 abb c bba

$w c w^R$
 Push \downarrow No \downarrow Pop
 ab c ba



push pop
 $w = aabcbac$

$w = \frac{ab}{\text{Push}} \frac{c}{\text{No}} \frac{ba}{\text{Pop}}$

$w = bacab$

b	for b
a	for a
z0	

a	for a
b	for b
z0	

\Rightarrow If we see the center 'c' then don't do anything compare the w with w^R strings.

Q. Construct PDA for given Palindrome.

② $L = \{ \underline{ww^R} \mid w \in (a,b)^+ \}$ Set of all evenlength Palindrome.

\Rightarrow ① Whenever the top of the stack is same as input symbol, then there is chance of center (or) matching

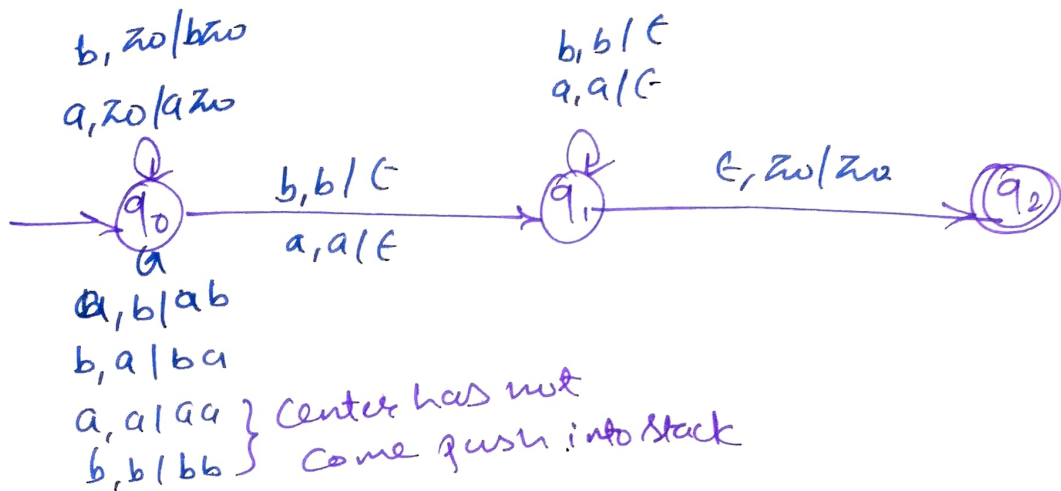
$w = \underline{abaa}ba$
 $\begin{matrix} \swarrow & \searrow \\ w & w^R \\ \text{Push} & \text{Pop} \end{matrix}$

② ex:- aa/aa so top & input symbol is same that doesn't mean there will be centre.

In this case -

$\delta(q_0, a, z_0) \begin{cases} \rightarrow \text{push} \\ \rightarrow \text{pop} \end{cases}$

$\delta(q_0, b, z_0) \begin{cases} \rightarrow \text{push} \\ \rightarrow \text{pop} \end{cases}$



$w = \underline{a b b a}$
 Push \downarrow
 Same Center has come.

b	pop for 'b'
a	pop for 'a'
z_0	

$\Rightarrow w = \underline{a a a a}$

$w = (q_0, \uparrow a a a a, z_0)$

$\delta(q_0, \uparrow a a a, a z_0) \Rightarrow \text{Push}$

Push \downarrow No center \quad Center \downarrow Pop

$(q_0, \uparrow a a, a a z_0)$

$(q_1, a a, z_0)$

At q_1 state $a, a / \epsilon$
 $b, b / \epsilon$; but here
 $a a, z_0$, so Dead configuration

Push \downarrow No center \quad Center \downarrow Pop

$(q_0, \uparrow a, a a a z_0)$

$(q_0, \uparrow a, a a z_0)$
 one a is pop

Push \downarrow \quad Pop

$(q_0, \epsilon, a a a a z_0)$
 X Dead configuration

$(q_1, \epsilon, a a z_0)$
 Dead configuration

(q_1, ϵ, z_0)
 2nd a is pop

(q_2, ϵ, z_0) Accept

③ Design a PDA that accepts all palindrome strings over $\Sigma = \{a, b\}$ & specify simulation for string $ab a$ (6M)

⇒ A palindrome will be of the form —

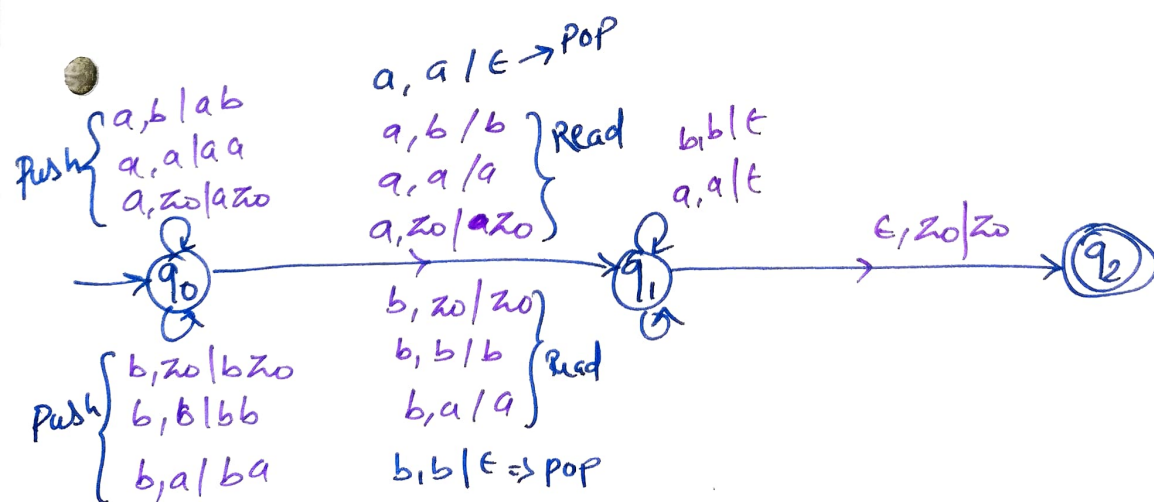
① ww^R ⇒ Even length palindrome ⇒ ε ^{middle character}

② waw^R } ⇒ odd length palindrome ⇒ a
 ③ wbw^R } ⇒ b

① $w = aba$

② $aw = aa \Rightarrow w \in w$
 $\Rightarrow a \in a$

③ $w = aabbaa$



Simulation for $w = ab a$

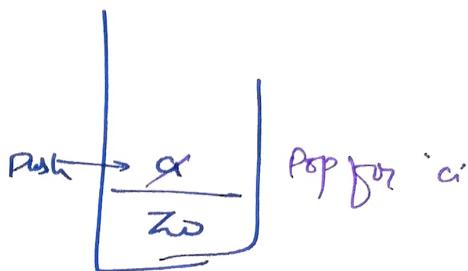
① $w = \underline{ab a}$

$w = a \ b \ a$
 Push \rightarrow Read \rightarrow Pop

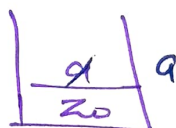
$\delta(q_0, a, z_0) = (q_0, a z_0) \text{ Push}$

$\delta(q_0, b, a) = (q_1, a) \text{ Read}$

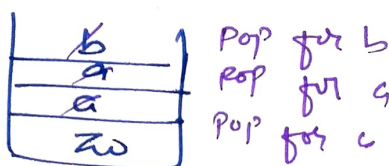
$\delta(q_1, a, a) = (q_1, \epsilon) \text{ Pop}$



② $w = a a = \cancel{a} \epsilon a$

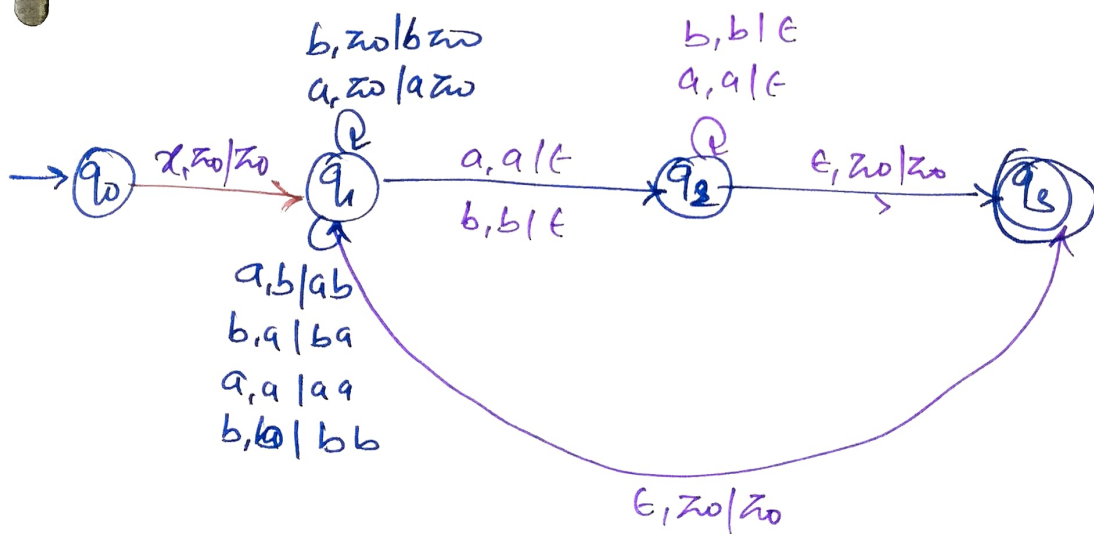


③ $a a \underline{b} b a a$



④ $L = \{ x w w^R \mid w \in (a, b)^* \}$

$\rightarrow L = \{ \epsilon, x, \cancel{a} a b b a, \dots \}$



$w = x a b b a \cdot \epsilon$, $w = x \cdot \epsilon$

$q_0 \rightarrow q_1 \rightarrow q_1 \rightarrow q_2 \rightarrow q_2 \rightarrow q_3$

$q_0 \rightarrow q_1 \rightarrow q_3$

* Equivalence of PDA & CFG

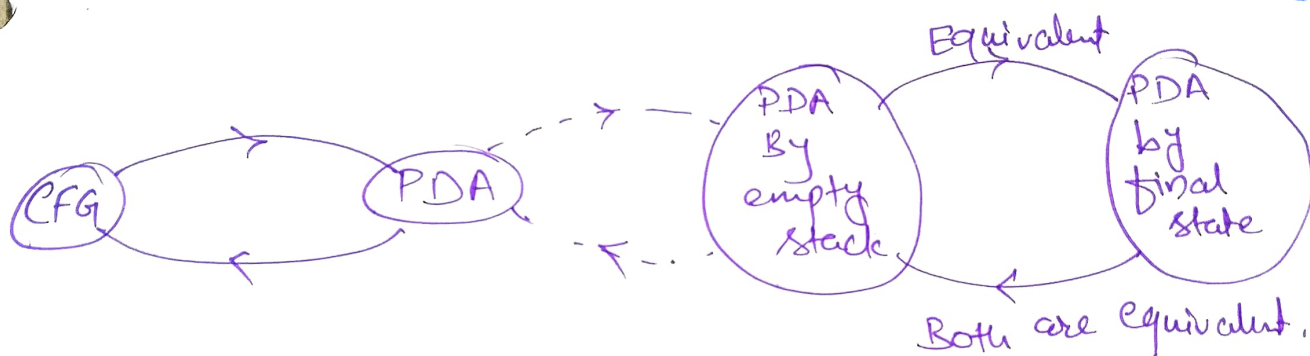
* CFG to PDA Conversion*:-

CFG

PDA

$$G = \{V, T, P, S\}$$

$$M = \{Q, \Sigma, \Gamma, \delta, q_0, z_0, F\}$$



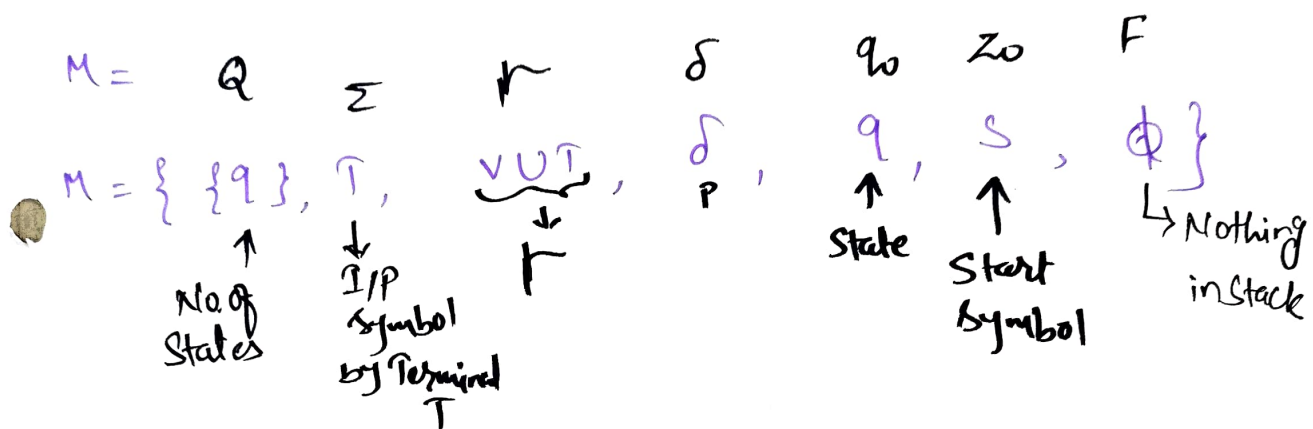
⇒ If CFG is equivalent to PDA & there is grammar equivalent to PDA then there is equivalence between them.

⇒ The class of languages accepted by PDA is exactly the class of CFG languages.

P:- $A \rightarrow \alpha$ is production

$A \in V, \alpha \in (V \cup T)^*$

\Rightarrow PDA accepting $L(G)$ by empty stack is given by -



where,

$\delta: \textcircled{1} \delta(q, \epsilon, A) \Rightarrow (q, \alpha)$
 \uparrow Pop of Stack
 $\rightarrow A$ replaced by α i.e. Right side prodⁿ of CFG

$\textcircled{2}$ For every Terminal $a \in T$ (pop opⁿ)

$\delta(q, a, a) \Rightarrow (q, \epsilon) \Rightarrow \text{Pop}$