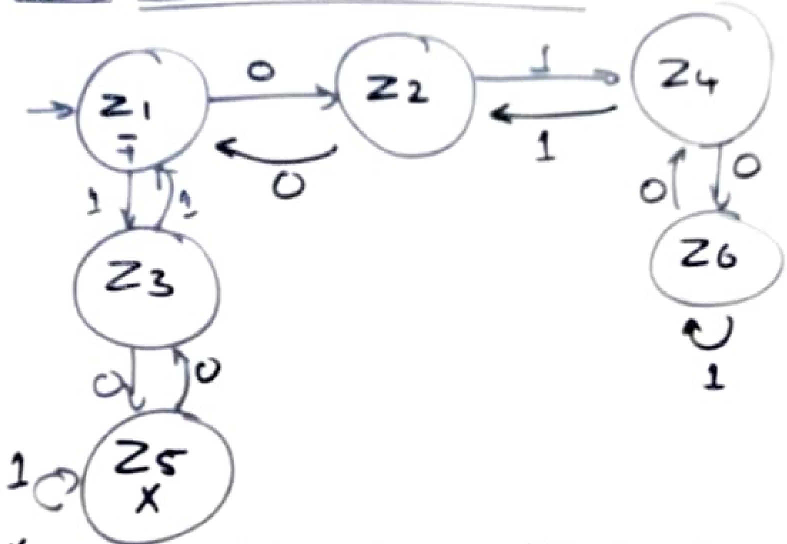
Q1 DFA Minimization:-



States	0	1
$\rightarrow z_1$	z_2	z_3
z_2	z_1	z_4
z_3	z_5	z_1
z_4	z_6	z_2
z_5	z_3	z_5
z_6	z_4	z_6

Partition:-

$z_1 | z_2 z_3 z_4 z_5 z_6 |$

$z_1 | z_2 | z_3 z_4 z_5 z_6 |$

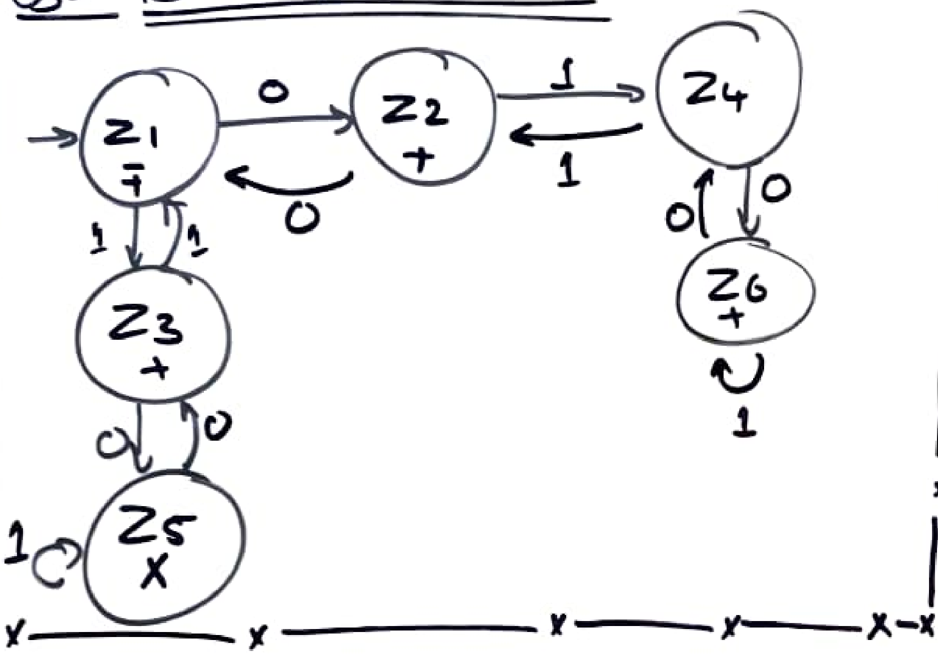
$z_1 | z_2 | z_3 | z_4 z_5 z_6 |$

$z_1 | z_2 | z_3 | z_4 | z_5 z_6 |$

$z_1 | z_2 | z_3 | z_4 | z_5 | z_6$

DFA is already Minimized

Q1 DFA Minimization:-



states	0	1
∓ z_1	z_2	z_3
+ z_2	z_1	z_4
+ z_3	z_5	z_1
z_4	z_6	z_2
z_5	z_3	z_5
+ z_6	z_4	z_6

Partition:-

$z_1 z_2 z_3 z_6 \mid z_4 z_5$

$z_1 \mid z_2 z_3 z_6 \mid z_4 \mid z_5$

$z_1 \mid z_2 \mid z_3 z_6 \mid z_4 \mid z_5$

$z_1 \mid z_2 \mid z_3 \mid z_4 \mid z_5 \mid z_6$

DFA Already Minized

Q2 Regular Grammers-

a) $a^n b^m$: $(n+m)$ is even   n&m odd , n&m even

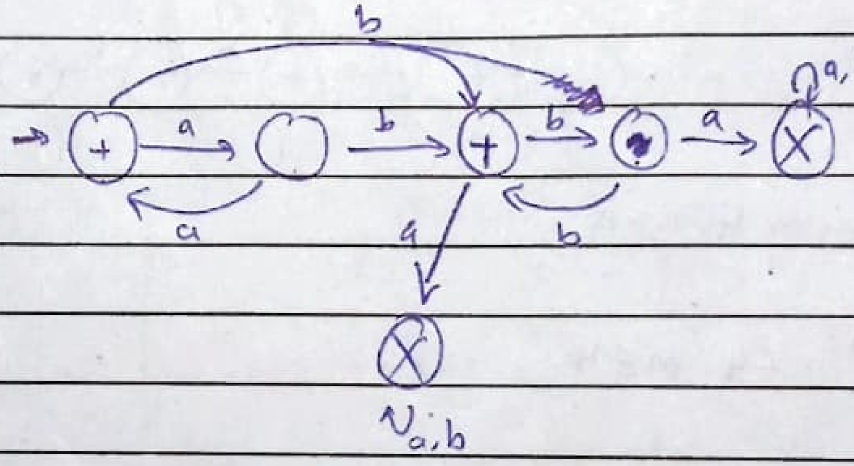
RE: $a(aa)^* b(bb)^* + (aa)^*(bb)^*$

CFG: $S \to aAbB \mid AB \mid A \mid B$

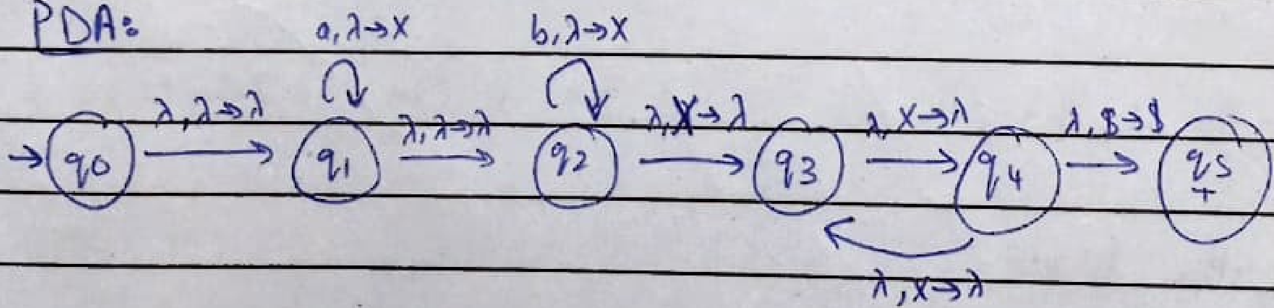
$A \to aaA \mid \lambda$

$B \to Bbb \mid \lambda$

DFA:



PDA:



~~RG: App~~

b) $a^n b^m$, $n \geq 4$, $m \leq 3$

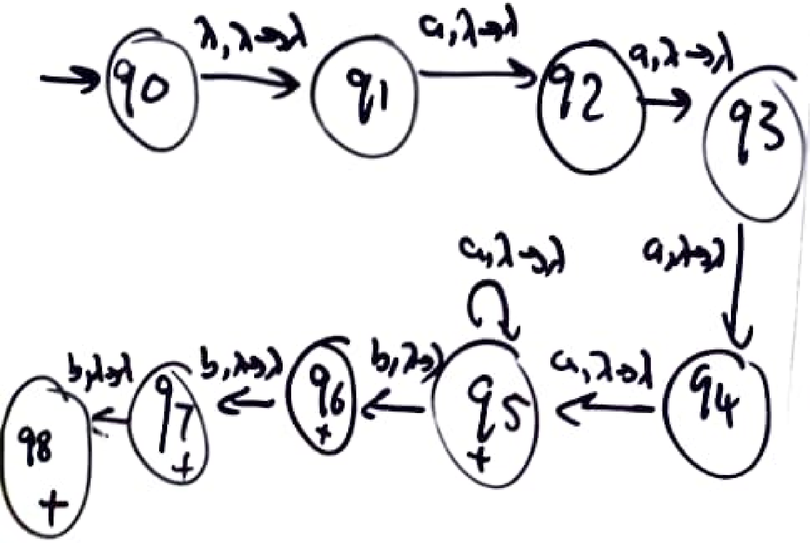
CFG:

$S \to AB$

$A \to aaaa \mid aA$

$B \to b \mid bb \mid bbb \mid \lambda$

PDA:



c) $a^n b^m$ $n < 4$, $m \leq 4$

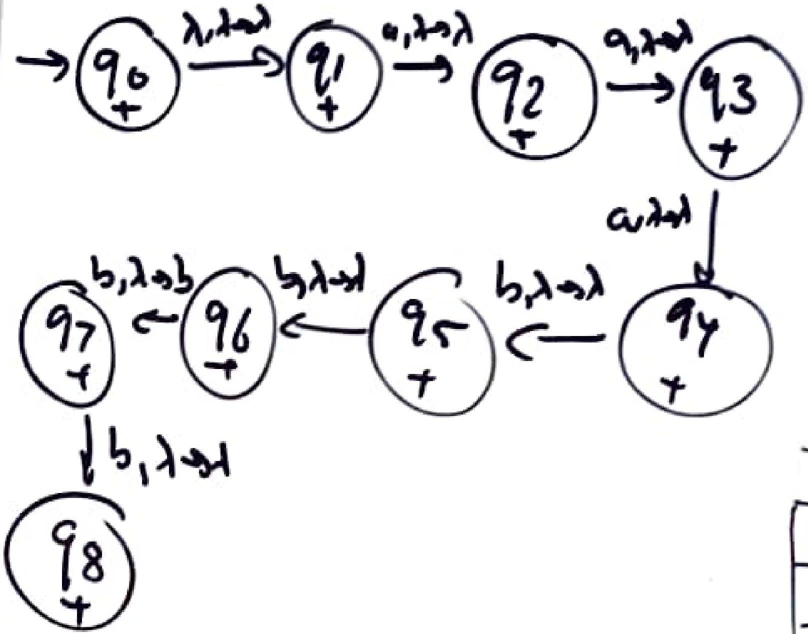
CFG:

$S \to AB$

$A \to a \mid aa \mid aaa$

$B \to b \mid bb \mid bbb \mid bbbb$

PDA:



d)

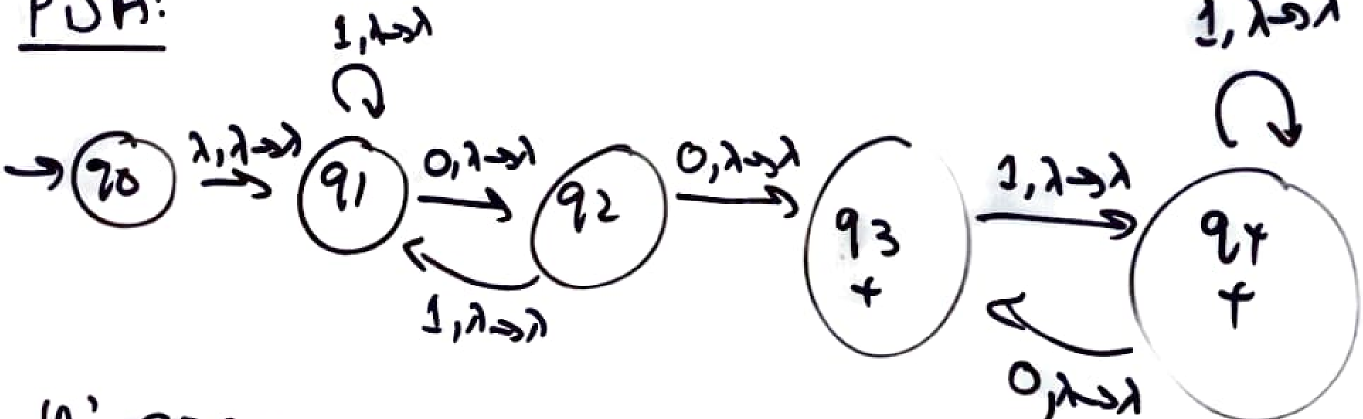
CFG:

$S \to A00B$

$A \to 1A \mid 01A \mid \lambda$

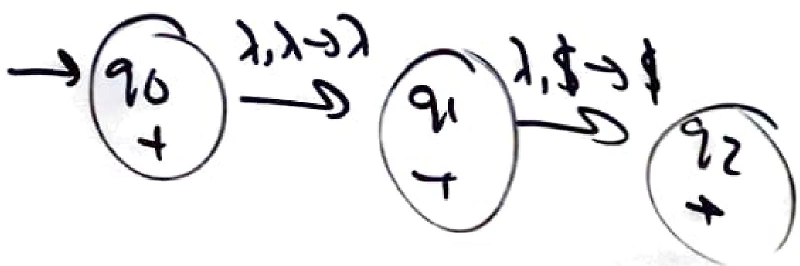
$B \to B1 \mid B10 \mid \lambda$

PDA:



f) **CFG:** $S \to \lambda$

PDA:



(e) All strings that contain atleast 1 occurence of each symbol in alphabet.

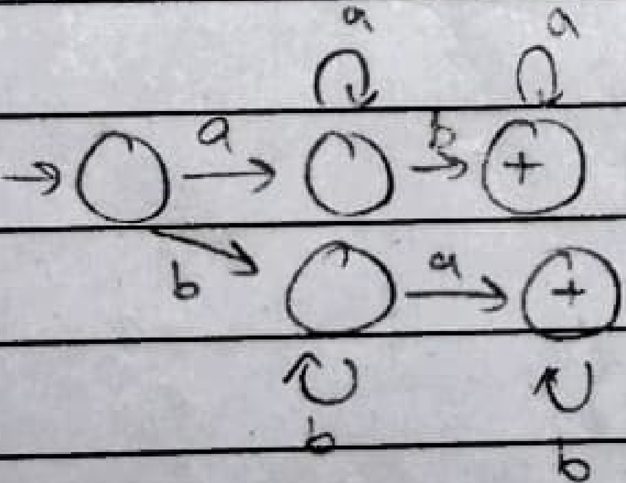
RE: $(a+b)^* (ab+ba)(a+b)^*$

CFG:

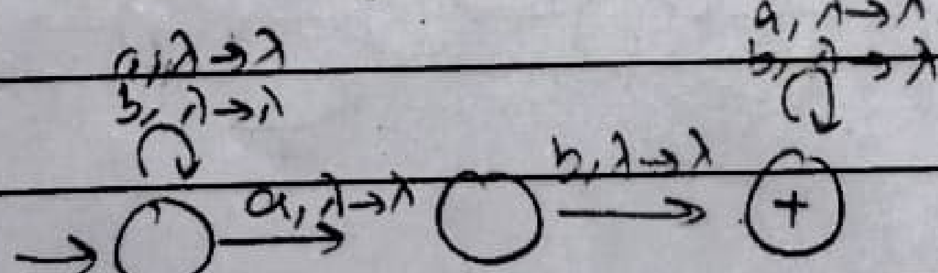
$S \rightarrow AabA \mid AbaA$

$A \rightarrow$ ~~ab~~ $aA \mid bA \mid \lambda$

DFA:



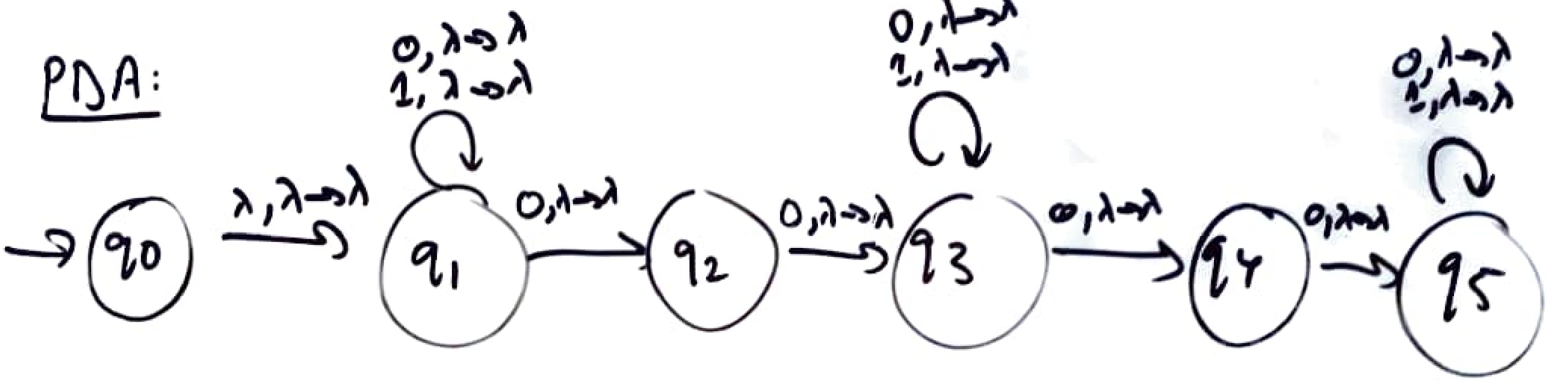
PDA:



g) $S \to A00A00A$

$A \to 0A \mid 1A \mid \lambda$

PDA:

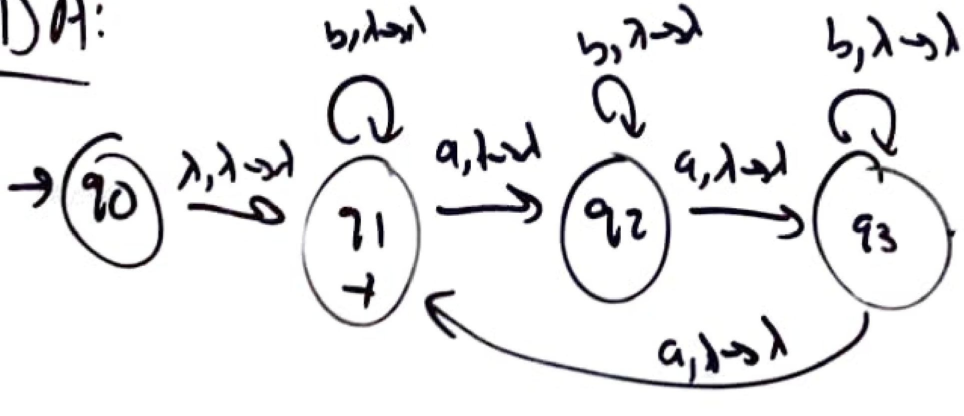


h) CFG:

$S \to AaAaAaAS \mid \lambda$

$A \to bA \mid \lambda$

PDA:

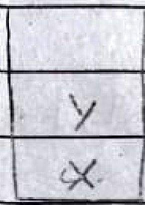


Q3

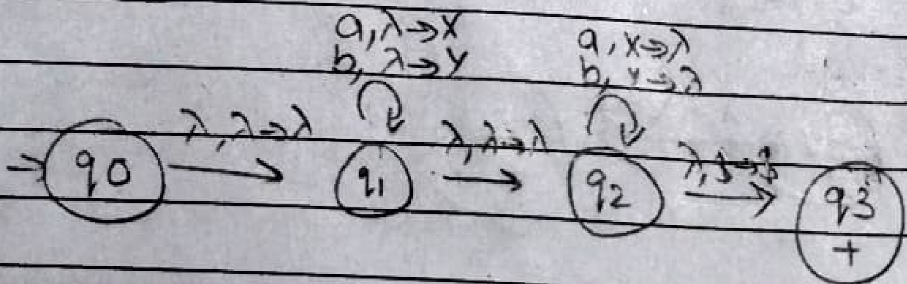
a) CFG:

$S \to aSa \mid bSb \mid \lambda$

1a 4b a

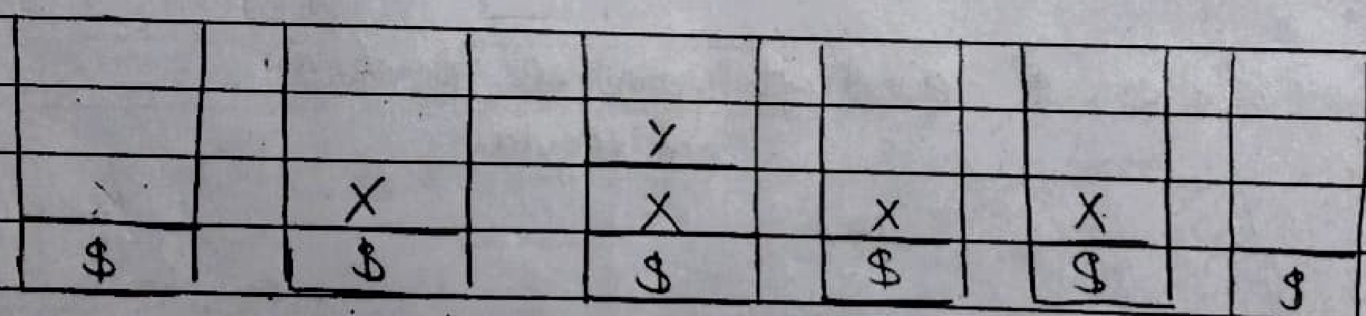


PDA:



Stack Operation

Test String: abba



$q_1, a, \lambda \to X$ $\quad$ $q_1, b, \lambda \to Y$ $\quad$ $q_2, Y \to \lambda$ $\quad$ $q_2, X \to \lambda$ $\quad$ $\lambda, \$ \to \$$

Pumping lemmas:

$a^n b^n b^n a^n$ $\quad$ let $n=2$

$|xy| \leq 2$ $\quad$ $\underbrace{a}_{x}\underbrace{a}_{y}\underbrace{bbbbaa}_{z}$

$xy^0z = abbbbaa$ reject, therefore not regular.

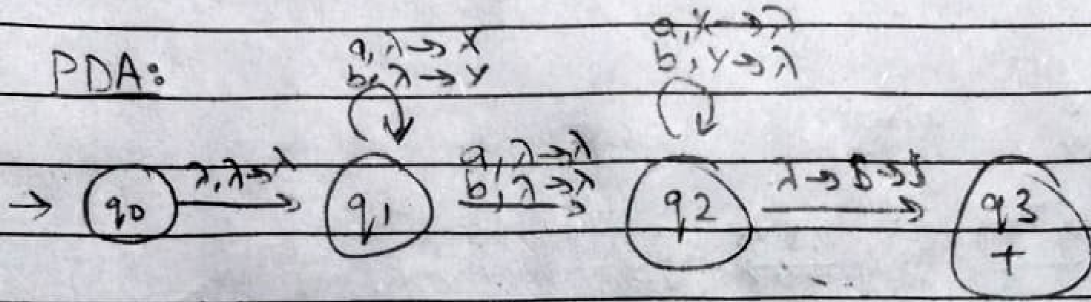
SOLO

b)

CFG:

S → aSa | bSb | a | b

PDA:



Pumping Lemma:

$a^n b^n a^n$ Let $n = 3$

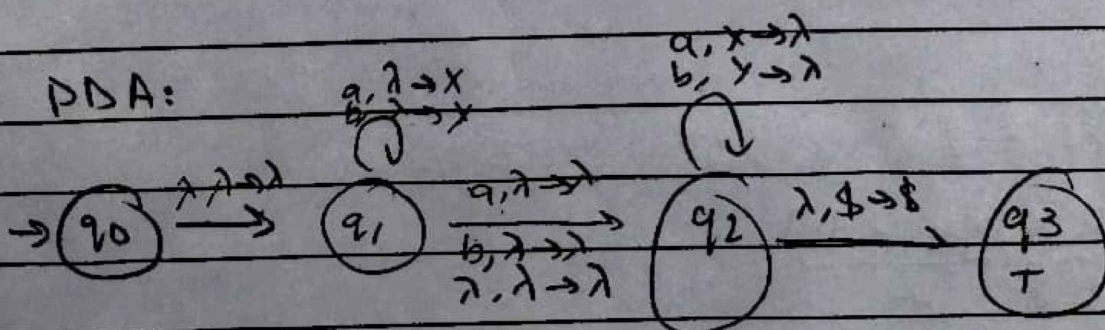
$\underbrace{a}_{x}\underbrace{aa}_{y}$ bbb aaa $|xy| \leq 3$

abbbaaa ∉ odd length palindrome therefore not regular.

c) CFG:

S → aSa | bSb | a | b | λ

PDA:



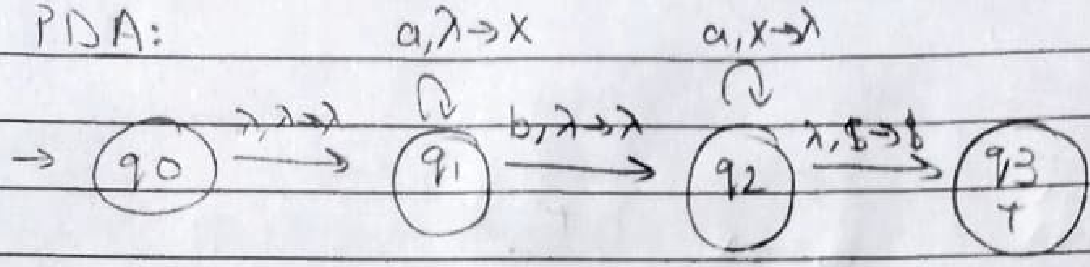
SOLO

ii) $a^n b a^n$

CFG:

$S \to aSa \mid b$

PDA:



Pumping lemma:

Let n = 2

$\underbrace{a}_{x}\underbrace{a}_{y}\underbrace{baa}_{z}$

$|xy| \leq n$, $|xy| \leq 2$

Pump y 0 times: abaa doesn't exist in $a^n b a^n$, therefore not Regular

iii) ww: $w \in \{a,b\}^*$

Not Possible Not CFG

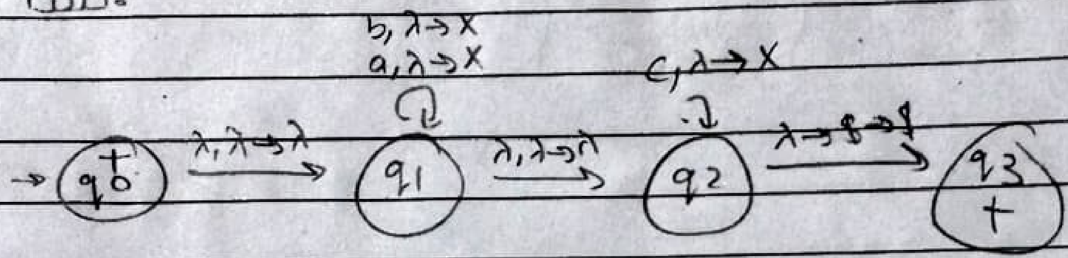
f) $\{a^n b^m c^{n+m}\}$, $n \geq 0, m \geq 0$

CFG:

$S \to aSc \mid \lambda \mid B$

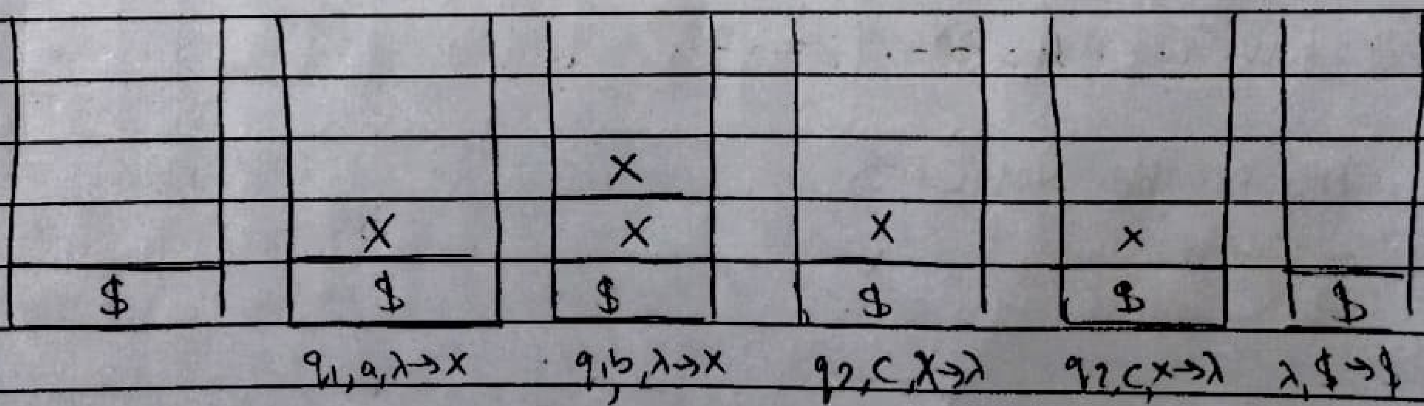
$B \to bBc \mid \lambda$

PDA:



Stack Operations:

Test String abcc



Date ______

Pumping Lemma:

Let $n=2$ $m=3$

$\underbrace{a}_{x}\underbrace{a}_{y}\underbrace{bbbccccc}_{z}$

$|xy| \leq 2$

pump y 0 times $abbbccccc \notin a^n b^m c^{n+m}$

therefore not regular.

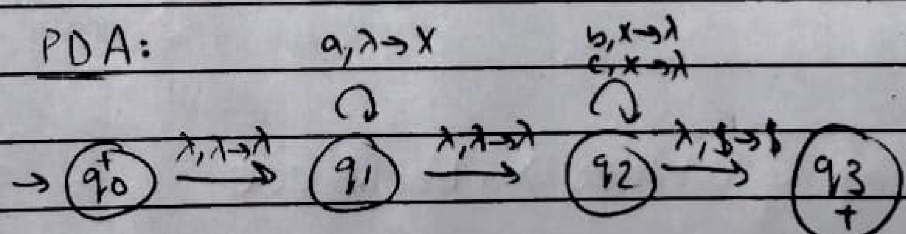
g $a^{n+m} b^n c^m$

CFG:

$S \to aSc \mid B \mid \lambda$

$B \to aBb \mid \lambda$

PDA:



Pumping Lemma:

Let $n=2$, $m=3$

aaaaa bb ccc $\quad$ $\underbrace{a}_{x}\underbrace{a}_{y}\underbrace{aaabbccc}_{z}$

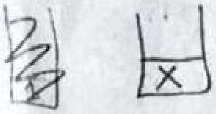
$|xy| \leq 2$

pump y 0 times : $aaaabbccc \notin a^{n+m} b^n c^m$

Not Regular

SOLO

Date ____________



h $a^n b^{n+m} c^m$

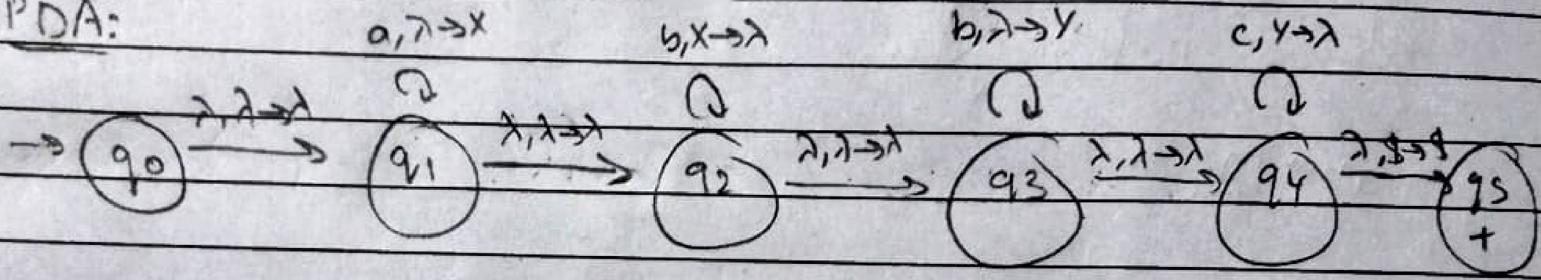
CFG:

$S \rightarrow AB$

$A \rightarrow aAb \mid \lambda$

$B \rightarrow bBc \mid \lambda$

PDA:



Pumping Lemma:

Let $n = 2$, $m = 3$

$|xy| \leq 2$

$\underbrace{a}_{x}\underbrace{a}_{y}\underbrace{bbbbbccc}_{z}$ pump y 0 times => a bbbbb ccc

a bbbbbccc $\notin a^n b^{n+m} c^m$ therefore not regular

SOLO

a bb   aSbb   aB

Date ________

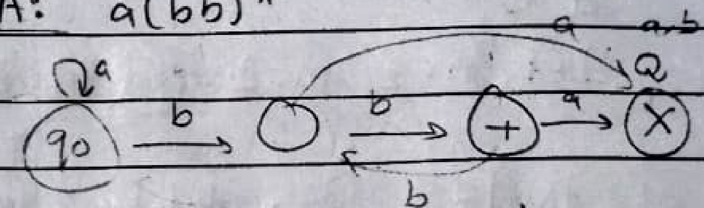
i) $a^n b^{2m}$

a(bb)*

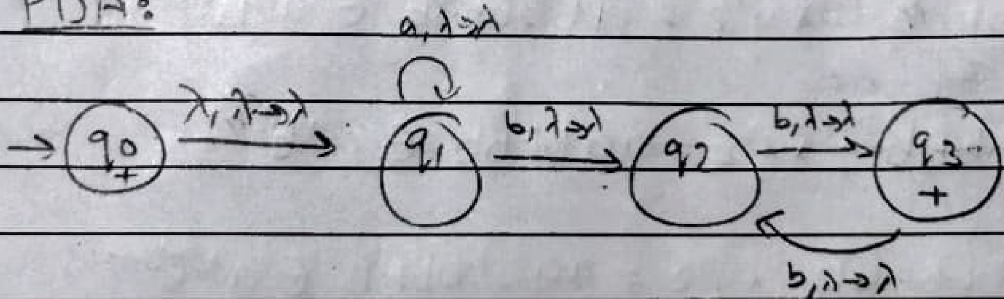
CFG:

$S \to AB$
$A \to aA \mid \lambda$
$B \to bbB \mid \lambda$

DFA: $a^*(bb)^*$

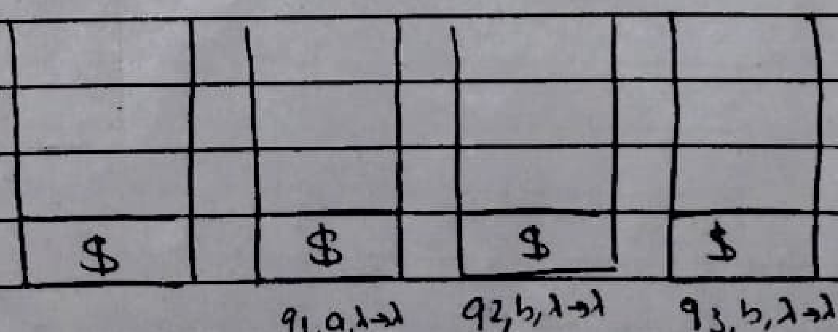


PDA:



Stack Operations

Test string: abb



SOLO

Date________ $\underbrace{a}_{x}\underbrace{b}_{y}\underbrace{b}_{z}$

Pumping Lemma:

$a^n b^{2m}$

Let ① $n=2, m=2$, ② $n=2, m=3$, ③ $n=3, m=2$, ④ $n=3, m=3$

① $|xy| \le 2$, $\underbrace{a}_{x}\underbrace{a}_{y}\underbrace{bbbb}_{z}$; $xy^0z = abbbb \in a^n b^{2m}$

② $|xy| \le 2$, $\underbrace{a}_{x}\underbrace{a}_{y}\underbrace{bbbbbb}_{z}$; $xy^0z = abbbbbb \in a^n b^{2m}$

③ $|xy| \le 3$, $\underbrace{aa}_{x}\underbrace{a}_{y}bbbb$; $xy^0z = aabbbb \in a^n b^{2m}$

④ $|xy| \le 3$, $\underbrace{aa}_{x}\underbrace{a}_{y}bbbbbb$; $xy^0z = aabbbbbb \in a^n b^{2m}$

Let $n=1, m=2$, cannot take place because $\underbrace{a}_{x}\underbrace{b}_{y}b$ no loop in $|xy|$

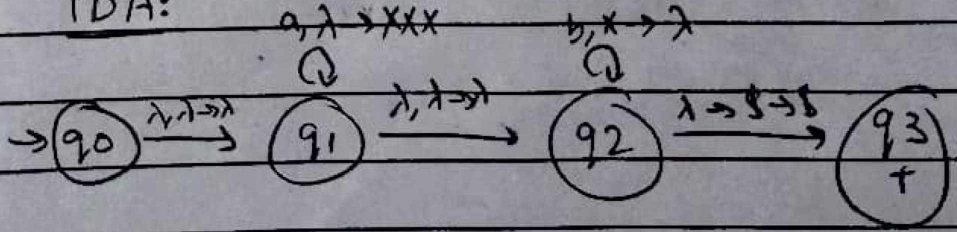
therefore Regular

j) $a^{2n} b^{3n}$

CFG:

$S \to aaSbbb \mid \lambda$

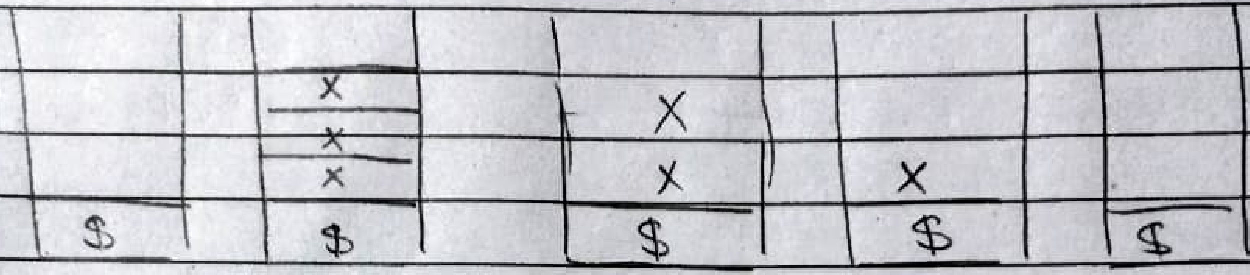
PDA:



Date

Stack Operations:-

test string aabbb



$q_1, a, \lambda \to xxx$ $\quad$ $q_2, b, x \to \lambda$ $\quad$ $q_2, b, x \to \lambda$

Pumping Lemma:-

Let $n = 2$

$\overbrace{a}^{x}\overbrace{a}^{y}\overbrace{aabbbbbb}^{z}$.

$|xy| \leq 2$

$xy^0z = aaabbbbbb \notin a^{2n}b^{3n}$ therefore not Regular.

SOLO

Date

Q4 1)

S → abS | abA | abB
A → cd
B → aB
C → dc

remove B → aB & ~~B~~ S → abB ~~unreachable~~ ungeneratable

S → abS | abA
A → cd
C → dc

remove C → dc unreachable

S → abS | abA
A → cd

Let ~~ab =~~ X → ab, C → c, D → d, E → a, F → b

S → XS | XA
A → CD
X → EF
C → c
D → d
E → a
F → b

2) S → ABC | a
A → b
B → c
C → d
E → e
F → f
G → g

remove E → e, F → f, G → g unreachable

S → ABC | a
A → b
B → c
C → d

Let X → AB

S → XC | a
A → b
B → c
C → d
X → AB

SOLO

Date

Remove $X \to SBD$ unreachable, $A \to Bad$, $A \to bSX$, $A \to a$.

3) $S \to aB \mid bX$	$S \to aB \mid bX$
$A \to Bad \mid bSX \mid a$	
$B \to aSB \mid bBX$	$B \to aSB \mid bBX$
$X \to SBD \mid aBX \mid ad$	$X \to aBX \mid ad$

Remove $B \to aSB \mid bBX$, $X \to aBX$, $A \to Bad$ can't generate a string

$S \to bX$

$X \to ad$

Let $C \to a$, $D \to b$, $E \to d$

$S \to DX$

$X \to CE$

$C \to a$

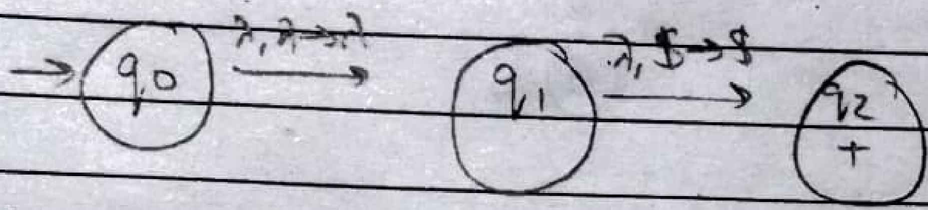
$D \to b$

$E \to d$

Q5 a) $S \to XS \mid \lambda$ X & A is unreachable.

$A \to aXb \mid Ab \mid ab$

$S \to \lambda$



b) PDA Not Possible

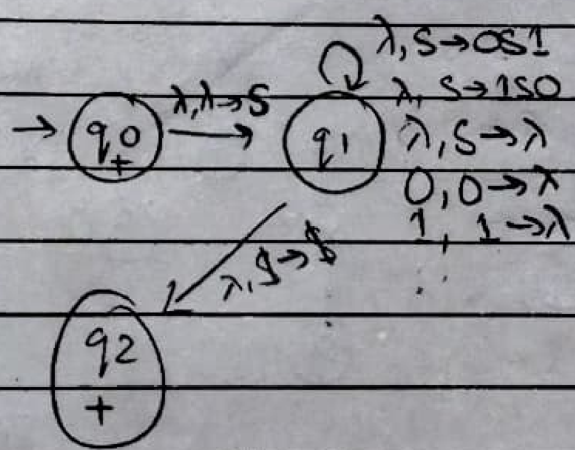
c) $S \to 0S1 \mid 1S0 \mid \lambda$

$S \to 0SX \mid 1SY \mid \lambda$

$X \to 1$

$Y \to 0$

} Same

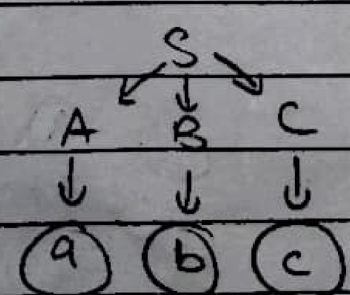


Q6 a) $S \to ABC$

$A \to a$

$B \to b$

$C \to c$



No ambiguity because there is only 1 Derivation tree.

aS
aaS

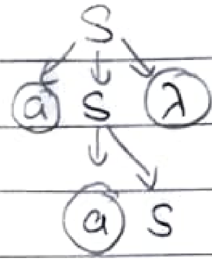
Date ________

Q6b

Test string aa

$S \rightarrow aS \mid \lambda$

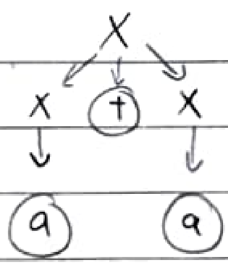
No ambigivity only 1 Derivation Tree

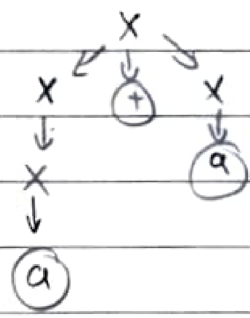


Q6c

$X \rightarrow X+X \mid X^*X \mid X \mid a$

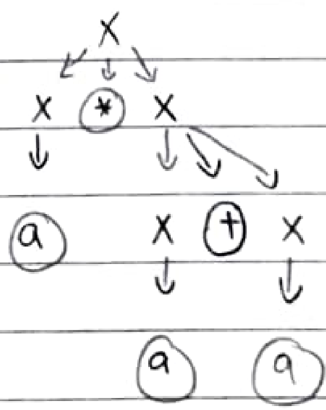
Test tring a+a

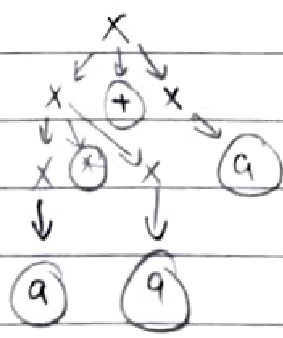




Multiple Derivation Tree's
Ambigious.

Test sting a*a+a





Multiple Derivation Trees
Ambigious.