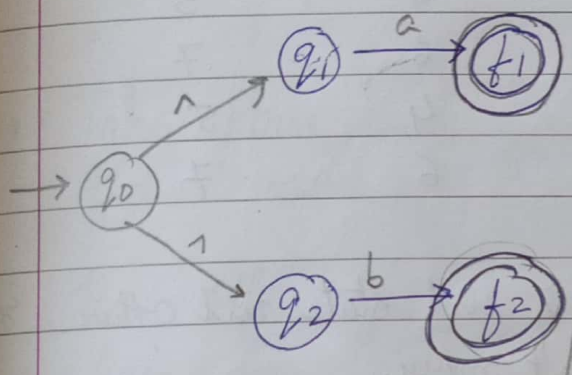
R.E. to NFA-Λ

(a) $[(ab)^*b + ab^*]^*$

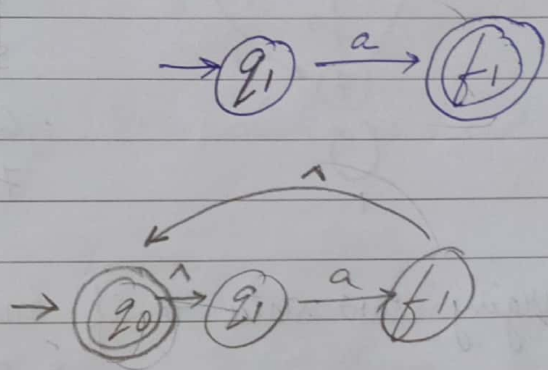
$\Rightarrow$ Kleen's Theorem.

Union : $a+b$



Kleene : a^*

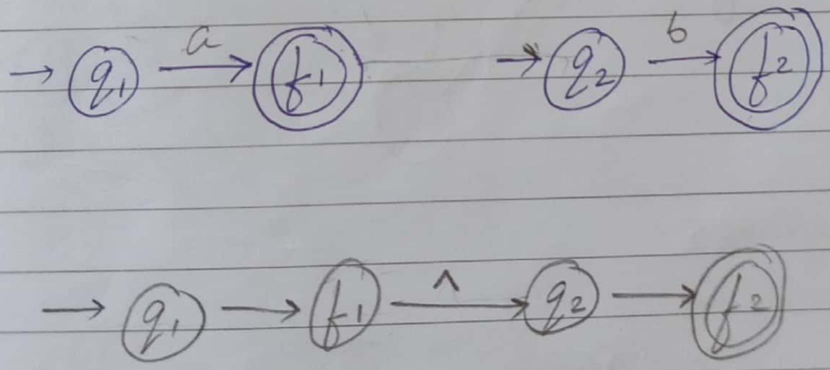
Step 3: Starting state q_0 becomes your accepting state.



Step 1: Add new starting state q_0 and add Λ transition from q_0 to q_1.

Step 2: Add Λ transition from all accepting state to starting state by removing acceptance of existing acceptance state.

Concatenation : $a \cdot b$

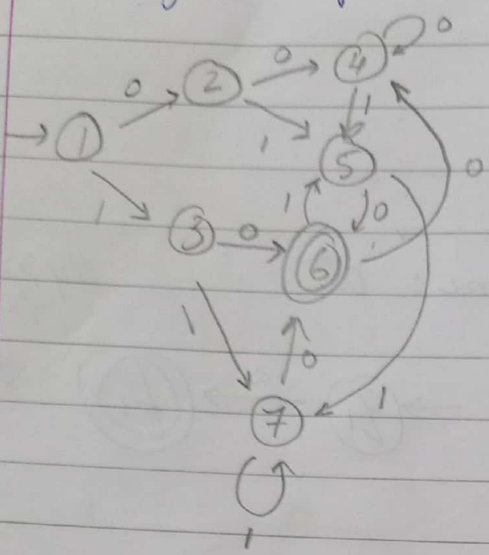


Step 1:
Remove accepting from f_1

Step 2:
Add Λ transition from f_1 to q_2

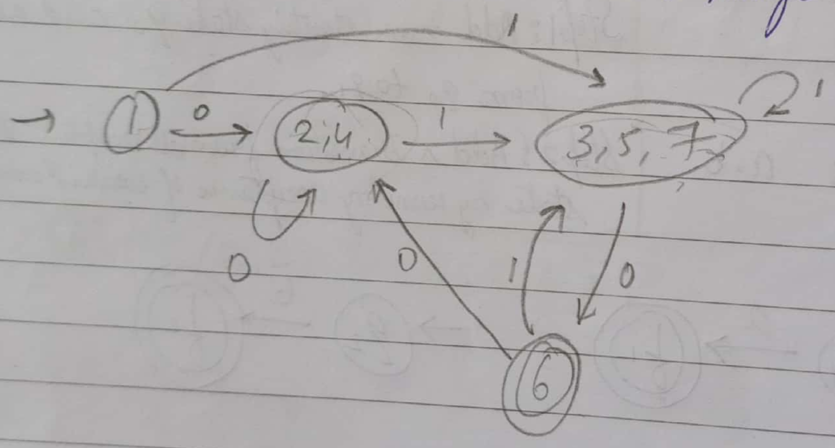
⇒ Minimization of an FA.

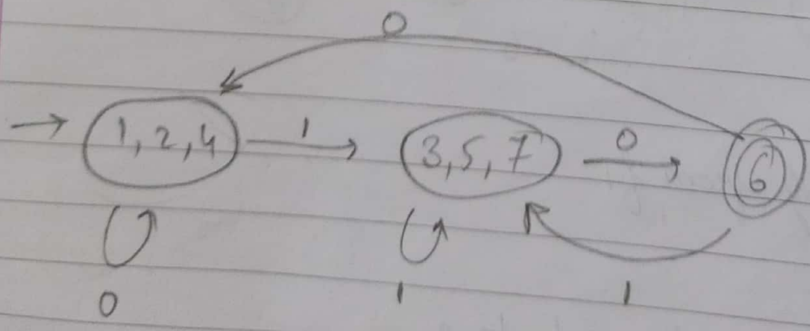
Q.



States	$\delta(q,0)$	$\delta(q,1)$
1	2	3
2	4	5
3	6	7
4	4	5
5	6	7
6	4	5
7	6	7

X wrong. = Merging two states → if one is end state and other is not we can't merge



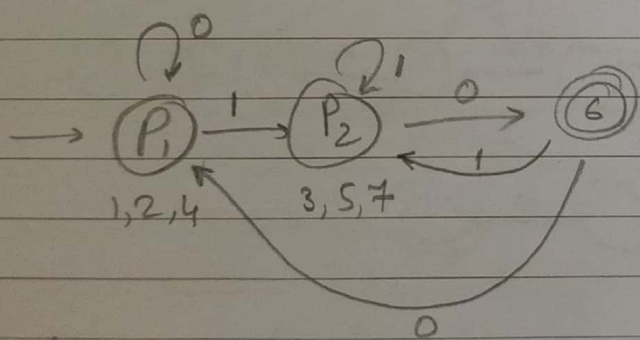


2	P_1					
3	2	2				
4	P_1	P_1	2			
5	2	2	P_2	2		
6	1	1	1	1	1	
7	2	2	P_2	2	P_2	1
	1	2	3	4	5	6

→ Take pairs and if only One state is end state then mark 1

→ For other pairs check (q, 0) and (q, 1) generated pair has only one end state then mark 2.

→ For making pairs, check all the columns columnwise.

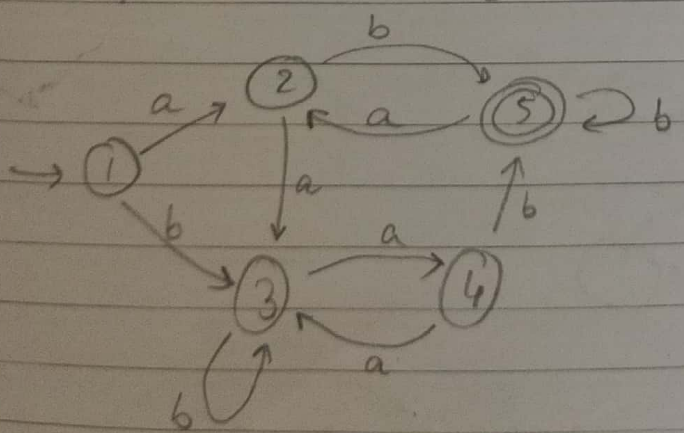


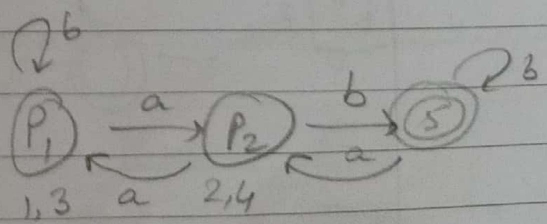
→ pairs such as (3,3), (6,6), (1,1) won't be considered.

TUT-5

Q3

(a)



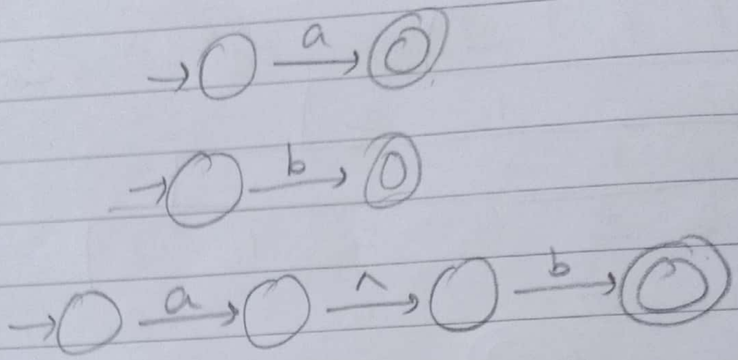


Minimized

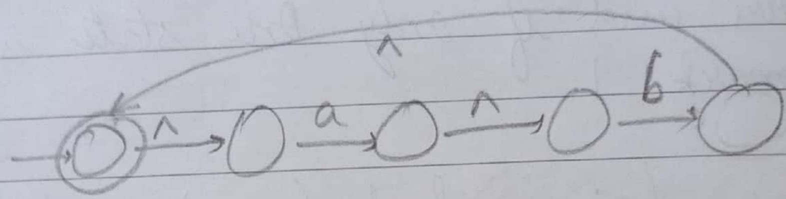
2	2			
3	P_1	2		
4	2	P_2	2	
5	1	1	1	1
	1	2	3	4

q. $[(ab)^* b + ab^*]^*$

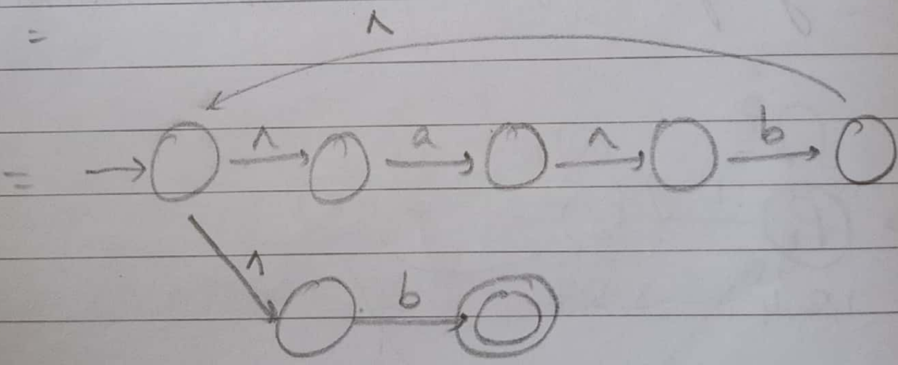
ab =



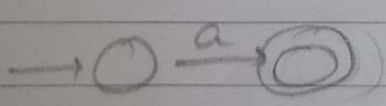
$(ab)^*$ =



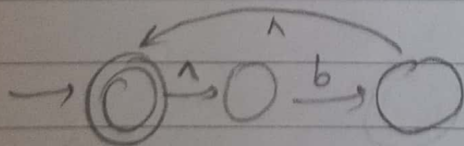
$(ab)^* b$ =



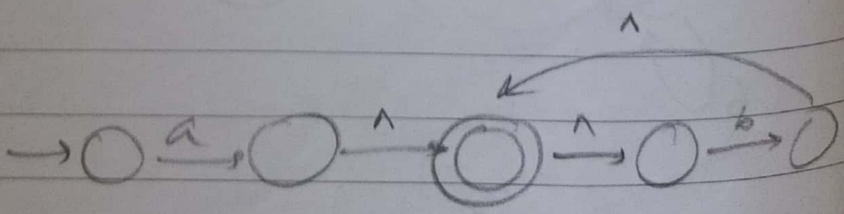
ab^* =



$\boxed{b^*}$ =

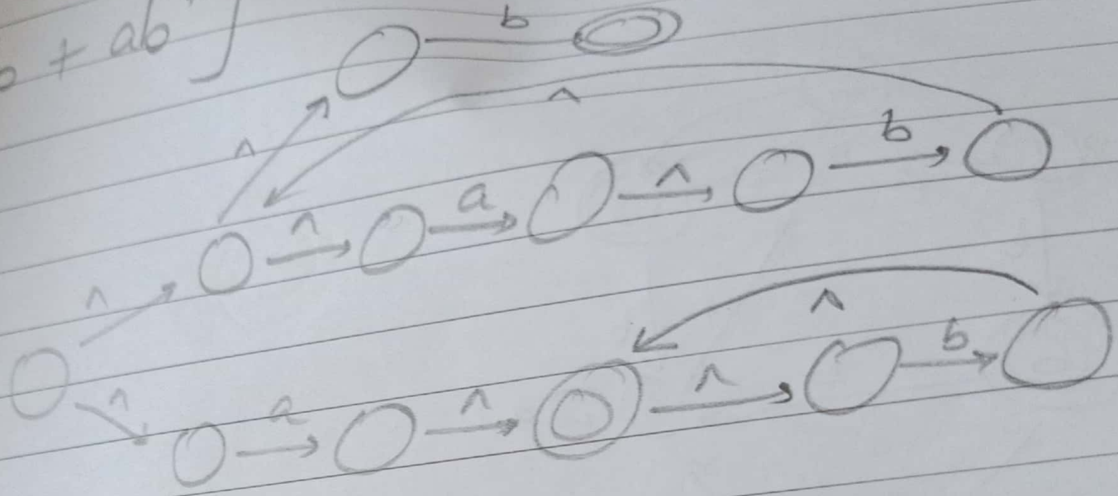


$\therefore ab^*$ =

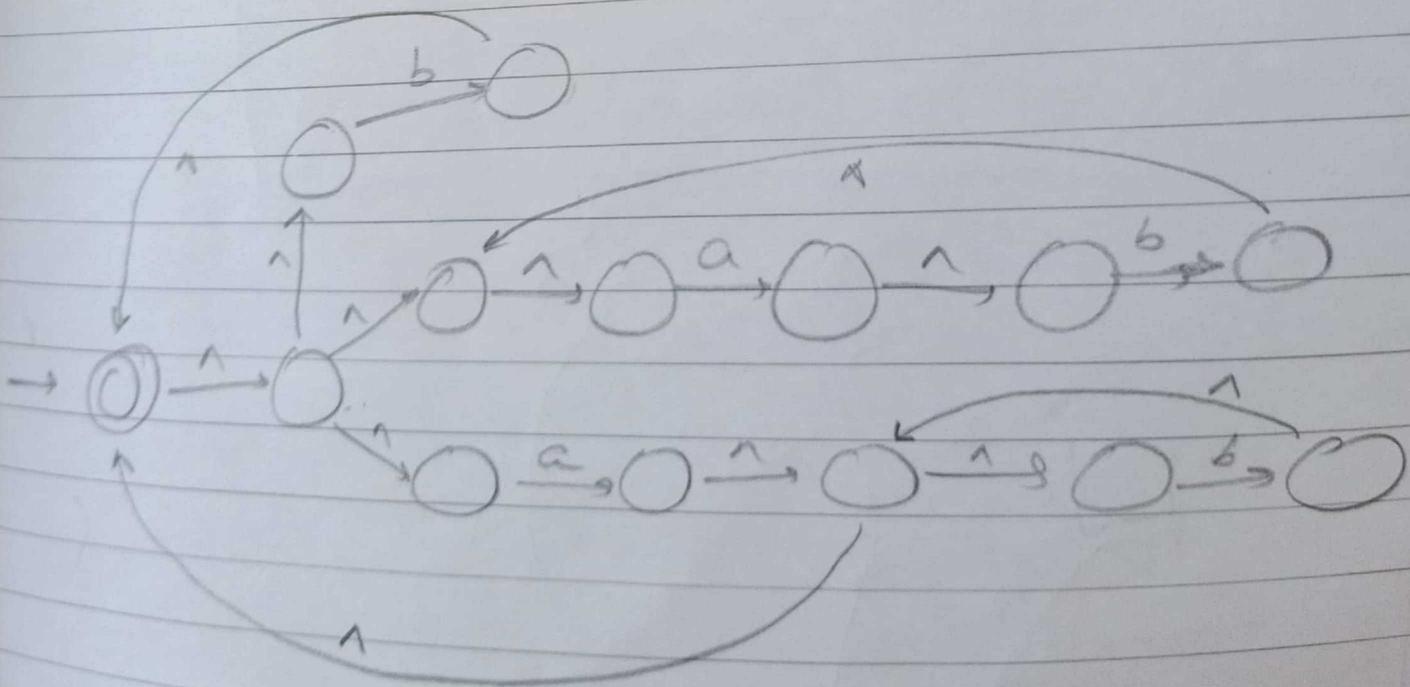


Hence finally :

$[(ab)^* b + ab^*]$ =



$[(ab)^* b + ab^*]^*$ = Final Answer

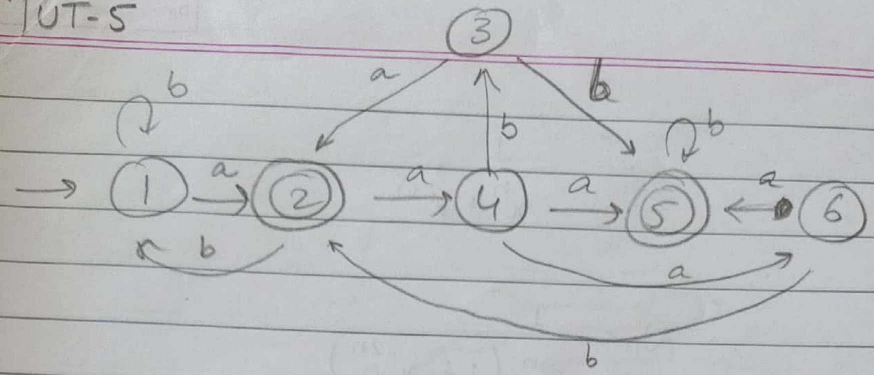


Page No.:
Date:

TUT-5

Q3

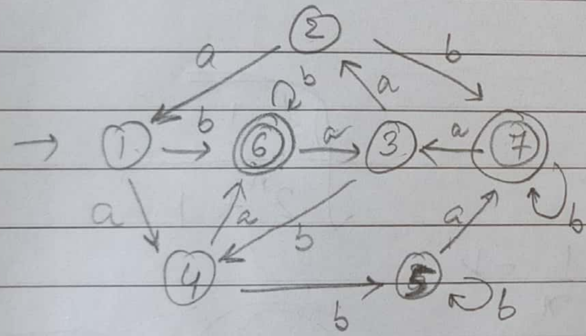
(b)



Here this is already minimised

	1	2	3	4	5
2	X				
3	X	X			
4	X	X	X		
5	X	X	X	X	
6	X	X	X	X	X

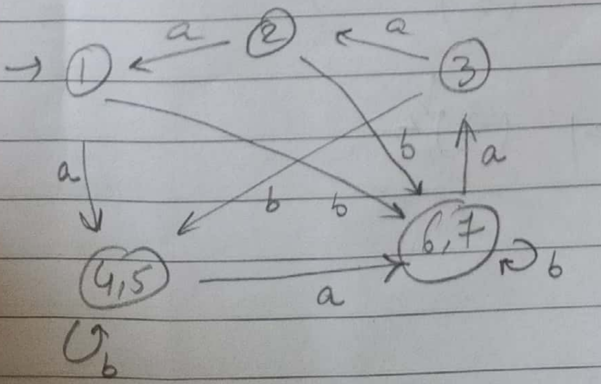
(d)



"•"

here (1,2) is marked because after the first iteration point (1,4) is marked and hence 1 & 2 on "a" we get (1,4).

	1	2	3	4	5	6
2	•					
3	X	X				
4	X	X	X			
5	X	X	X			
6	X	X	X	X	X	
7	X	X	X	X	X	



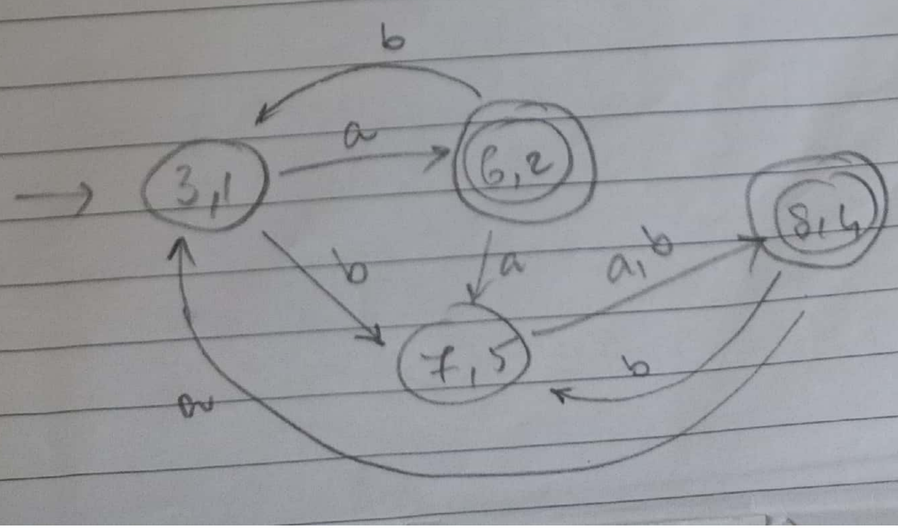
Here 1, 2 & 3 are not included in any merging set hence they exist independently. (pairs having 1, 2 & 3 all are marked).

b.

	q,a	q,b
1	2	7
2	5	3
3	6	5
4	1	5
5	8	8
6	7	1
7	8	4
8	3	7

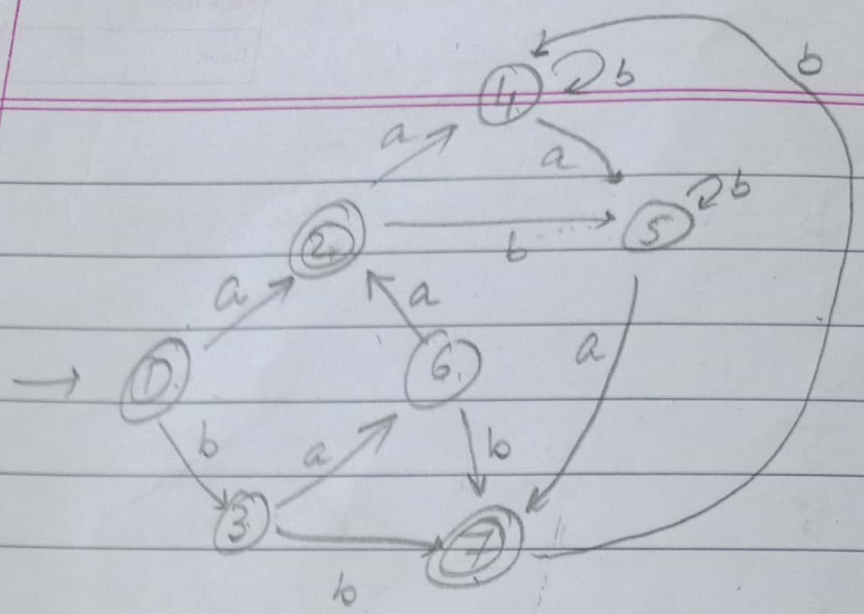
	1	2	3	4	5	6	7
2	×						
3	P_1	×					
4	×	×	×				
5	×	×	×	×			
6	×	P_2	×	×	×		
7	×	×	×	×	P_4	×	
8	×	×	×	P_3	×	×	×

3,1 P_1 6,2 P_2 7,5 P_4 8,4 P_3



Q3.

5.



Already Minimized.

	1	2	3	4	5	6
2	•					
3	X	X				
4	X	X	X			
5	X	X	X	X		
6	X	X	X	X	X	
7	•	•	X	X	X	X

	q_0, a	q_0, b
A	B	D
B	φ	C
C	E	D
D	E	D
E	E	D
φ	φ	φ

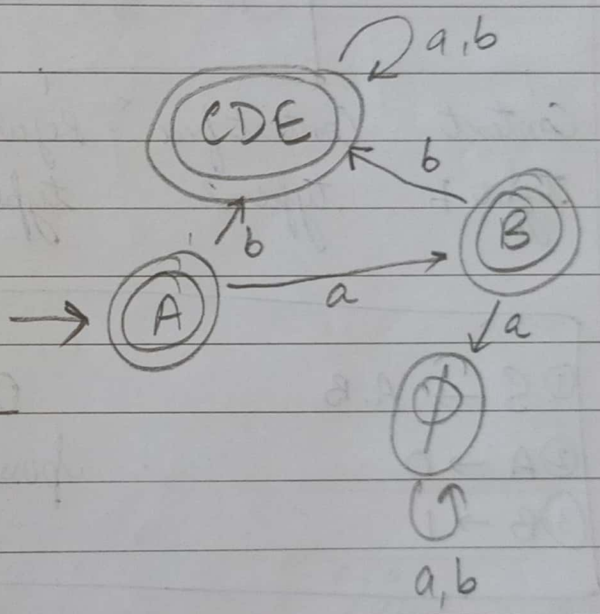
Tut-5

Q1.

1.

q	$\delta(q, A)$	$\delta(q, B)$
A	B	D
B	ϕ	C
C	E	D
D	E	D
E	E	D
ϕ	ϕ	ϕ

	A	B	C	D	E
B	x				
C	x	x			
D	x	x	P1		
E	x	x	P1	P1	
ϕ	x	x	x	x	x



Context free Grammar (CFG)

Grammer

- Restricted
  - Context sensitive type 1
  - Context free type 2
  - Regular type-3
- unrestricted type-0

① $S \to A.B$
② $A \to 0$
③ $B \to 1$

01 possible

011 not possible

type-0

$\alpha \to \beta$

α, β can be terminals / non-terminals

type-1

$\alpha A \beta \to \alpha x \beta$

$A \to x$

type-2

$A \to \alpha$

A = non-terminal

α = non-terminal / terminals.

type-3

$A \to a$

$A \to aX$

CFG having 4 tupple $G = (V, \Sigma, S, P)$

$V = S, A, B$

$\Sigma = 0, 1$

$S = S \in V$

P = production rules.

Eg. ① CFG for either a or b. = $a+b$ $S \to a/b$ '/' slash = or.

② for a^* $S \to \wedge / aS$

③ $(ab)^+$ $S \to ab / abS$

④ $(ab)^*$ $S \to abS / \wedge$

⑤ $(a+b)^*$ $S \to \wedge / aS / bS$

⑥ $a^* b^*$ $S \to \wedge / aS / bS$.

⑦ $a(a+b)^*$ $S \to a / aS / Sb / abS$ $S \to aX$, $X \to aX / bX / \wedge$

⑧ a^* / b^* $S = A/B$ $A \to aA / \wedge$ $B \to bB / \wedge$

⑨ $(011+1)^* (01)^*$ = $S \to A.B$

Page No.:
Date:

10. at least 3 times a.

$S \rightarrow XaXaXaX$

$X \rightarrow aX \mid bX \mid \wedge$

$X = (a+b)^*$

11. ~~Stated~~ Starts and ends with same symbol.

~~0S0 | 1S1 | 1S | 0S | Λ~~

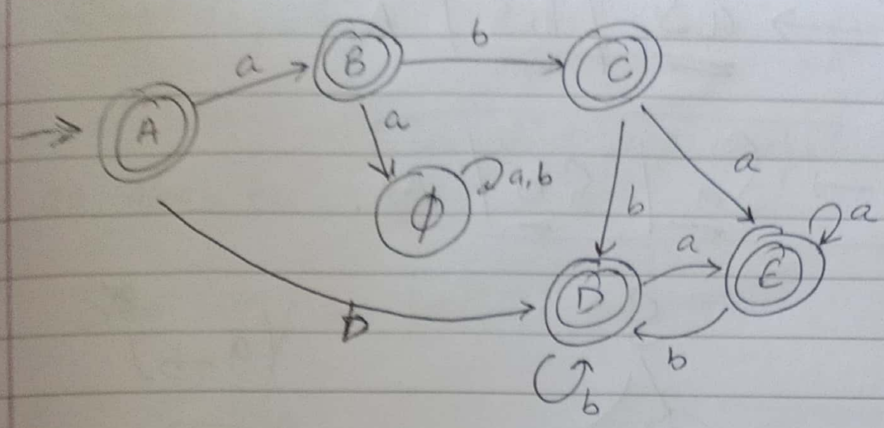
$S \rightarrow 0A0 \mid 1A1 \mid 1 \mid 0$

$A \rightarrow 0A \mid 1A \mid \Lambda$

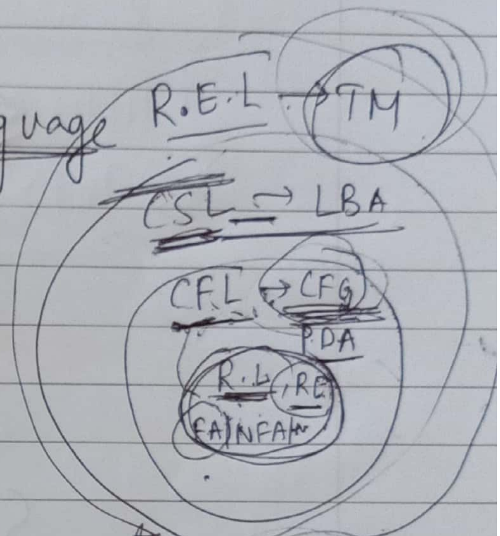
12. Palindrome odd length / even length.

13. Equal no of zeros and ones.

$S \rightarrow \cancel{0S1} \mid \wedge \mid \cancel{1S0} \mid 1S0S \mid 0S1S.$



Tutorial - 6



Q2.

1. $S \to aSa \mid bSb \mid \Lambda$

Even length palindrome   Non-regular.

abba, baaaab, aa, bb, Λ, baab, ... etc.

2. $S \to aSa \mid bSb \mid a \mid b$

Odd length palindrome

aba, bab, aaa, ababa, a, b, etc ..

3. $S \to aSb \mid bSa \mid \Lambda$

Alternate a, b consecutive a, b

ab, ba, abab, baba, b, b, b

$a^n b^n c^n$

$a^* b^*$

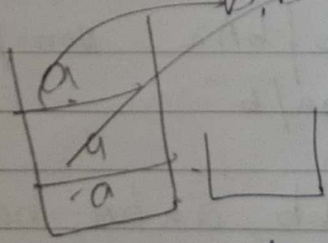
$a^n b^n \quad 0 \le n \le 3$

$\Lambda + ab + aabb$

aaabbb

Non Regular

Context free

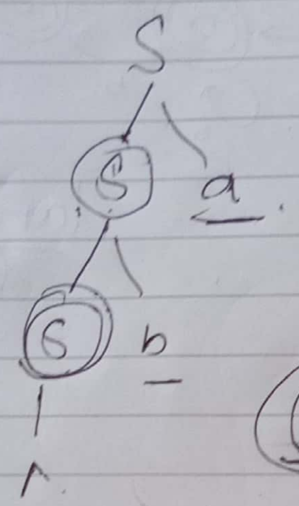


$a^n b^n c^n$

Recursive Defi —

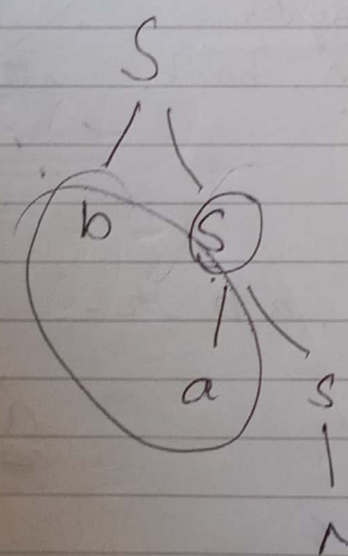
$S \rightarrow aS \mid bS \mid \Lambda$

$\boxed{S \rightarrow Sa \mid Sb \mid \Lambda}$



$(a+b)^*$

ba



4. $S \rightarrow aSa \mid bSb \mid aAb \mid bAa$ Non-palindrome.
$A \rightarrow aAa \mid bAb \mid \Lambda \mid a \mid b$

S = ab, ba, aab, bba, abb, aaba, baaabb, etc
~~aaaa, bbbb~~.

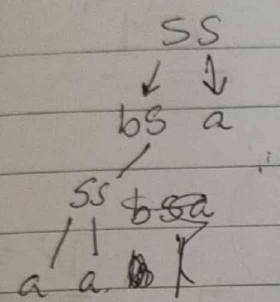
→ aba & bab not possible

5. $S \rightarrow aS \mid bS \mid a$

last dijit is a compulsory.

aa, aba, ba

6. $S \rightarrow SS \mid bS \mid a$.



baaa, ba, aa, aba, abba, ...

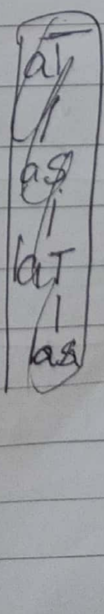
7. $S \rightarrow SaS \mid b$.

$\rightarrow$ SaSaSaS

$\rightarrow$ bababab, bab, babab.

8. $S \rightarrow aT \mid bT \mid \wedge$

$T \rightarrow aS \mid bS$ even length

aa, bb, abba, $\wedge$, aaba, aaaa, bbbb  , aabb

8. $S \rightarrow 0B \mid 1A \mid \wedge$ Equal numbers of 0's and 1's.

$A \rightarrow 0S \mid 1AA$

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

0A — 0S — 0B — 1S

0B — 0BB — 1S 1S

0B

~~[illegible]~~, 0011,

000111

2. $S \rightarrow 0S1 \mid 1S0 \mid SS \mid \wedge$

6.4.

(i) → Set of odd length strings in $\Sigma = \{a,b\}^*$ with middle symbol a.

(ii) → Set of even length strings over $\Sigma\ \{a,b\}^*$ with two middle symbols equal.

(iii) → The set of odd length strings in $\{a,b\}^*$ whose first, middle and last symbols are same.

(i) Ans. $S \rightarrow aSa \mid aSb \mid bSb \mid bSa \mid a$

(ii) Ans. $S \rightarrow aSa \mid aSb \mid bSb \mid bSa \mid aa \mid bb$

~~(iii) Ans. $S \rightarrow aSaSa \mid bSbSb \mid$ [illegible] $a+b$~~

(iii) $S \rightarrow aTa \mid bUb$

$T \rightarrow aTb \mid bTa \mid bTb \mid aTa \mid a$

$U \rightarrow bUb \mid bUa \mid aUb \mid aUa \mid b$

6.5.

a) $S \rightarrow S01S \mid S10S \mid \Lambda$

b) $S \rightarrow 0S1 \mid 1S0 \mid 01S \mid 10S \mid S01 \mid S10 \mid \Lambda$

number of 0 = number of 1.

a → 1100

b → 00111100

CFG for english language
declarative sentence where you have subject, verb, object

$a^i b^j c^k \mid i = j + k$

$a^j a^k b^j c^k$

$a^k a^j b^j c^k$

$S \rightarrow aSc \mid T$

$T \rightarrow aTb \mid \Lambda$

$S \rightarrow XY$

$X \rightarrow aXb \mid \Lambda$

$Y \rightarrow bYc \mid \Lambda$

Recursive def^n

① $(a,b)^*$ — Regular

$S \rightarrow \wedge / aS / bS$

1. $\wedge \in L$
2. for any $S \in L$, $aS \in L$
   " $S \in L$, $bS \in L$
3. No other string are in L

② Language of Palindrome

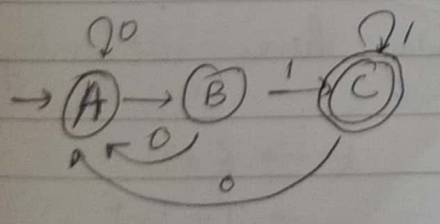
$S \rightarrow \wedge / a / b / aSa / bSb$

1. $\wedge, a, b \in L$
2. for any $S \in L$, $aSa \in L$ and $bSb \in L$
3. No other.....

③ $a^n b^n \quad n \geq 0$ — Non-Regular

$S \rightarrow \wedge / aSb$

1. $\wedge \in L$
2. for any $S \in L$, $aSb \in L$
3. No other.



$A \rightarrow 0A \quad B \rightarrow 0A \quad C \rightarrow 1C$

$A \rightarrow 1B \quad B \rightarrow 1C \quad C \rightarrow 0A$

011011

$A \rightarrow 0A$

$01B$

$011C$

$0110A$

$01101B \quad \cdot 011011C$ ← End state hence 011011 possible.

Derivation tree

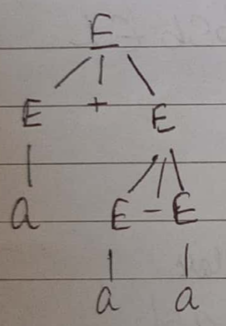
Eg. $E \rightarrow E+E \mid E-E \mid a$ Abiguous grammar.

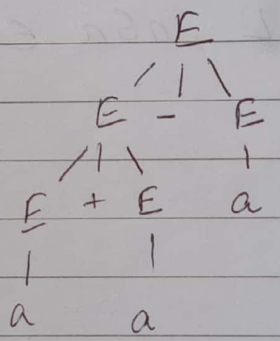
$E \rightarrow E+E$
$\rightarrow E+E-E$
$\quad a \quad a \quad a$

$\therefore a+a-a$

$E \rightarrow E-E$
$\rightarrow E+E-E$
$\quad a \quad a \quad a$

$\therefore a+a-a$

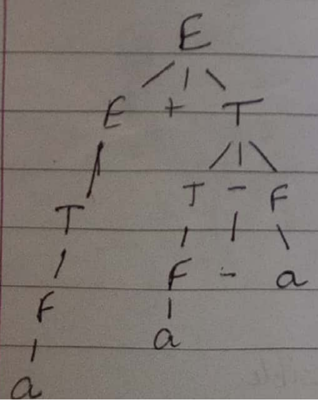




Eg. $E \rightarrow E+T \mid T$
$T \rightarrow T-F \mid F$
$F \rightarrow a$

$a+a-a$

Only one way hence not ambiguous



$a+a-a.$

$E \rightarrow E+T$
$\rightarrow T+T-F$
$F+F-a$
$a+a-a$

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Page No.:
Date:
YOUVA

Write CFG

1. $a^i b^j c^k \,/\, i = j+k$
2. $a^i b^j c^k \,/\, j = i+k$
3. $a^i b^j c^k \,/\, j=i$ or $j=k$.
4. $a^i b^j c^k / i=j$ or $j=k$.
8. $a^i b^j c^k / i \le j \le 2i$

1Ans. $a^{j+k} b^j c^k$

$a^k a^j b^j c^k$

$S \rightarrow aSc / T$

$T \rightarrow aTb / \Lambda$

$a^i b^j b^k c^k$

$S \rightarrow aSb / T$

$T \rightarrow bTc / \Lambda$

Q2. Ans: $A \rightarrow aAb / \Lambda$

$B \rightarrow bBc / \Lambda$

$S \rightarrow AB$

Q3. = Q4. $a^i b^i c^k$ $\quad$ $a^i b^k c^k$

$A \rightarrow aAb / \Lambda$ $\quad$ $P \rightarrow Pa / \Lambda$

$B \rightarrow BC / \Lambda$ $\quad$ $Q \rightarrow bQc / \Lambda$

$S_1 \rightarrow AB$ or $S_2 \rightarrow PQ$

$S \rightarrow AB / PQ$

$S \rightarrow S_1 / S_2$

5Ans Q. $a^i b^j c^k$ $\quad$ $i<j$ or $i>k$

$B \rightarrow bB / b$ $\quad$ $T \rightarrow aTb / \Lambda$

$C \rightarrow cC / c$ $\quad$ $U \rightarrow aUc / V$

$A \rightarrow aA / a$ $\quad$ $V \rightarrow bV / \Lambda$

$S \rightarrow TBC / AU$

$i<j$

$a^i b^i b^m c^k$, $m>0$

$A \rightarrow aAb / \Lambda$

$B \rightarrow bB / b$

$C \rightarrow cC / \Lambda$

$S_1 \rightarrow ABC$

$i>k$ $\quad$ $a^k a^m b^j c^k$

$P \rightarrow aPc / ab / \Lambda$ $\quad$ $m>0$.

$Q \rightarrow aQ / a$

$R \rightarrow bR / \Lambda$

$S_2 \rightarrow PQR$ $\quad$ $S \rightarrow S_1 / S_2$

→ Left most / right most derivation

$S \rightarrow A / B$ $\quad$ String 00101

$A \rightarrow 0A / \Lambda$

$B \rightarrow 0B / 1B / \Lambda$

$S \Rightarrow B$

0B

00B

001B

0010B

00101B → 00101

Page No.:
Date:

Q. $S \rightarrow aS / Sa / \wedge$
String aaaa.

$S \rightarrow aS$ ← right most
aaS
aaaS
aaaaS
aaaa

$S \rightarrow Sa$ ← left most
Saa
Saaa
Saaaa
aaaa

Q. $S \rightarrow SS / a / b$ Abiguous
String abba.

$S \rightarrow SS$
SS SS
a b b a.

Q. $S = A / B$ string ab. Ambiguous
$A \rightarrow aAb / ab$
$B \rightarrow abB / \wedge$

$S \rightarrow A$
ab
$S \rightarrow B$
abB
ab

Q. $S \rightarrow AB / C$ aabbccdd. Ambiguous
$A \rightarrow aAb / ab$
$B \rightarrow cBd / cd$
$C \rightarrow aCd / aDd.$
$D \rightarrow bDc / bc.$

$S \rightarrow AB$
aAb cBd
aabbccdd.

$S \rightarrow C$
aCd =aabbc
~~aaDdd~~
aaCdd
aa

Q. $S \to AS \mid aaB$ Ambiguous.

$A \to a \mid Aa$

$B \to b$

aab.

$S \to AB$ $S \to aaB$

AaB aab.

aab

Q $S \to a \mid abSb \mid aAb$ Ambiguous.

$A \to bS \mid aAAb$

abababb

$S \to aAb$ $S \to abSb$

~~aaAAbb~~ abaAbb

abSb. ababSbb

ababSbb ababab b

abababb.

Q. $S \to aSbS \mid bSaS \mid \wedge$ Ambiguous.

String abab

$S \to aSbS$ $S \to aSbS$

abSaSb $\wedge$

abab. ab aSbS

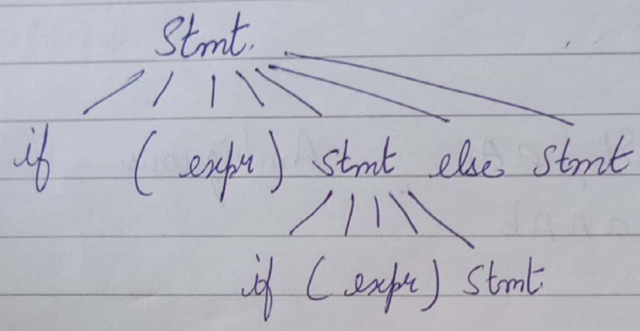
abSb.

Dangling else.

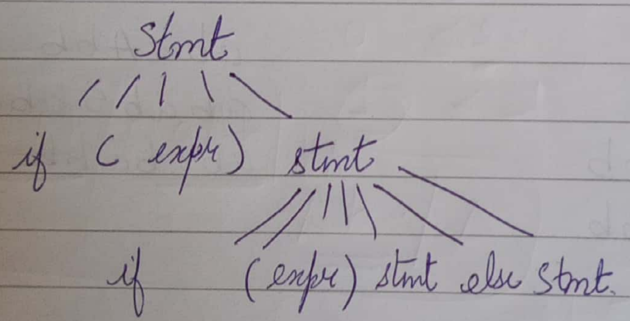
Q. Statement → if (expr) stmt /
if (expr) stmt else stmt /
other stmt.

Ambiguous.

String :- if (expr) if (expr) stmt;
else stmt



Or.



Q. Stmt → S_1 | S_2
S_1 → if (expr) stmt else stmt / other stmt
S_2 → if (expr) stmt / if expr) stmt else stmt.

Q. $E \to E+E \mid E*E \mid id$ ⟶ Ambiguous

$E \to E+T \mid T$
$T \to T*F \mid F$
$F \to id.$

unambiguous

id + id * id.

Normal forms

Chomsky Normal form (CNF)

How to remove $\wedge$

Q. $S \to S+a \mid S-a \mid \wedge$ — Nullable product as S ~~can~~ is having $\wedge$..

Ans. $S \to S+a \mid S-a \mid +a \mid -a$

Q. $E \to E+E \mid E*E \mid id \mid \wedge$

Ans. $E \to E+E \mid E*E \mid id \mid + \mid * \mid E+ \mid +E \mid E* \mid *E$

CNF

1. Remove Null Productions
2. Remove Unit production.
3. Right side with single terminal or two or more non-terminals.
4. Right side can have 2 non-terminals.

$E \to T \mid E+T$
here $E \to T$ is the unit production

Q. $E \to E+T \mid T$
$T \to T*F \mid F$
$F \to id$

Ans. $E \to E+T \mid T*F \mid id.$
$T \to T*F \mid id.$
$F \to id.$

$X \to CD$

Q. $S \to AACD$
$A \to aAb \mid \wedge$
$C \to aC \mid a$
$D \to aDa \mid bDb \mid \wedge$

1. $S \to AACD \mid ACD \mid AAC \mid C \mid CD \mid AC$ (AX)
$A \to aAb \mid ab$
$C \to aC \mid a$
$D \to aDa \mid bDb \mid aa \mid bb.$

$S \to AACD \mid ACD \mid AAC \mid aC \mid CD \mid AC \mid a$

$X_a C$ $\quad X_a \to a$

Page No.:
Date:

Tutorial-6.

$\overset{0,1}{}$ 1
0,1,2,3. 2

Q1.

7. $a^i b^j$ $i<j$ $j=i+m$

$a^i b^i b^m$
$Q \rightarrow aQb \mid \Lambda$
$P \rightarrow Pb \mid b$

$S \rightarrow QP.$

$a^i b^j \mid i \leq 2j$

~~$S \rightarrow aaSb \mid Sb \mid \Lambda$~~

$S \rightarrow aSb \mid aasb \mid aaasbb \mid Sb \mid b \mid ab$

6. $a^i b^j$ $i \leq 2j$ ~~$i=2j$ or $i=2j+m$~~

$A \rightarrow aaAb \mid$
$B \rightarrow aB$

$i \leq 2j$
$0 \leq 2\cdot 0$
$1 \leq 1$

$A \rightarrow aAb \mid aaAb \mid Ab \mid \Lambda$

$i=0$ $i=1$ $i=2$
$j=0$ $j=1$ $j=2$
$1 \leq 2(1)$ $2 \leq 4$

aaAb
aaab
ab aaAb

M	T	W	T	F	S	S

Page No.:
Date:
YOUVA

8. $a^i b^j$ $i \le j \le 2i$ $\wedge, ab, abb$

$0 \rightarrow 0$ $2 \rightarrow 2, 3, 4$
$1 \rightarrow 1, 2$ $3 \rightarrow 3, 4, 5, 6$

$3 \le \le 6$
$3\ 4\ 5\ 6$

$A \rightarrow aAb \mid aAbb \mid$ ~~aaAbbbb~~ $. \wedge$

$i \le j$

aaabbbb

aaabbbb

aaa bbbb

aaa

S

Q6. $\{a^i b^j \mid i \le 2j\}$

$$\begin{cases} i = 0, & j = 0, 1, 2, \ldots \\ i = 1, & j = 1, 2, 3, \ldots \\ i = 2, & j = 1, \ldots \\ i = 3, & j = 2, \ldots \end{cases}$$

$A \rightarrow aAb \mid aaAb \mid Ab \mid \wedge$

$L = \{a^i b^i \mid i \ge 0\}$

$x = uvw$ $x = 0^n 1^n$
$u = 0^n$ $v = 1^k$ $w = 1^{n-k}$

1) $uvw = 0^n 1^k 1^{n-k} = 0^n 1^n \in L$
2) $uv^2w = 0^n 1^{2k} 1^{n-k} = 0^n 1^k 1^n \notin L$

So L is not reguler.

Q. $S \to AaA \mid CA \mid BaB$

$A \to aaBa \mid CDA \mid aa \mid DC$

$B \to bB \mid bAB \mid bb \mid aS$

$C \to Ca \mid bC \mid D$

$D \to bD \mid \Lambda$

Remove Null.

Q. $S \to ABA$

$A \to aA \mid \Lambda$

$B \to bB \mid \Lambda$

$S \to ABA \mid AB \mid BA \mid B \mid A \mid AA$

$A \to aA \mid a$

$B \to bB \mid b$

Q. $S \to aSa \mid bSb \mid \Lambda$

$A \to aBb \mid bBa$

$B \to aB \mid bB \mid \Lambda$

$S \to aSa \mid bSb \mid aa \mid bb$

$A \to aBb \mid bBa \mid ab \mid ba$

$B \to aB \mid bB \mid a \mid b$

Q. $S \to A \mid B \mid C$

$A \to aAa \mid B$

$B \to bB \mid bb \mid \Lambda$

$C \to aCaa \mid D$

$D \to baD \mid abD \mid aa$

$S \to A \mid B \mid C$

$A \to aAa \mid aa \mid B$

$B \to bB \mid bb \mid b$

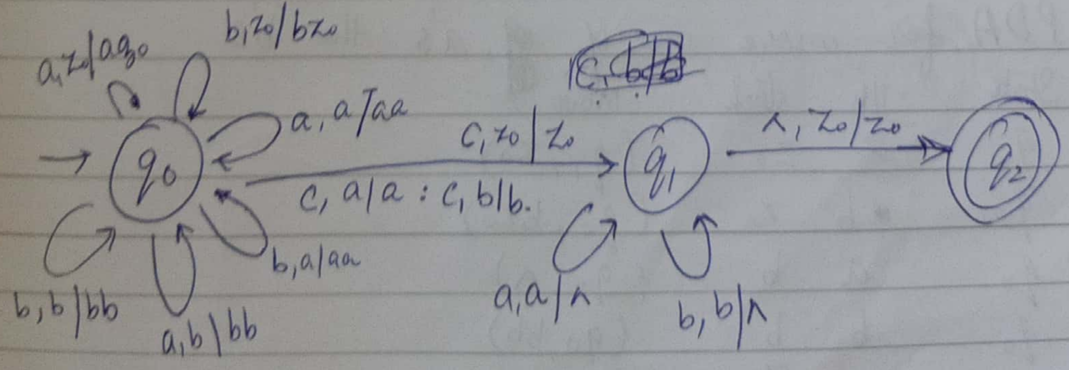
$C \to aCaa \mid D$ $\quad$ $D \to baD \mid aaD \mid aa$

Push Down Automata (PDA)

$q_0 \rightarrow$ Push
$q_1 \rightarrow$ Pop
$q_2 \rightarrow$ Accept

For Palindrome, odd length

State	i/p	stack	Move
q_0	a	Z_0	(q_0, aZ_0)
q_0	a	a	(q_0, aa)
q_0	b	Z_0	(q_0, bZ_0)
q_0	b	b	(q_0, bb)
q_0	a	b	(q_0, ab)
q_0	b	a	(q_0, ba)
q_0	c	Z_0	(q_1, Z_0)
q_0	c	a	(q_1, a)
q_0	c	b	(q_1, b)
~~q_0~~	~~$\wedge$~~	~~Z_0~~	
q_1	a	a	$(q, \wedge)$
q_1	b	b	$(q_1, \wedge)$
q_1	$\wedge$	Z_0	$(q_2, Z_0) \rightarrow$ accept.



$\vdash (q_0, abcba, Z_0)$
$\vdash (q_0, bcba, aZ_0)$
$\vdash (q_0, cba, baZ_0)$
$\vdash (q_1, ba, baZ_0)$
$\vdash (q_1, a, aZ_0)$
$\vdash (q_1, \wedge, Z_0) \longrightarrow q_2$

Q.

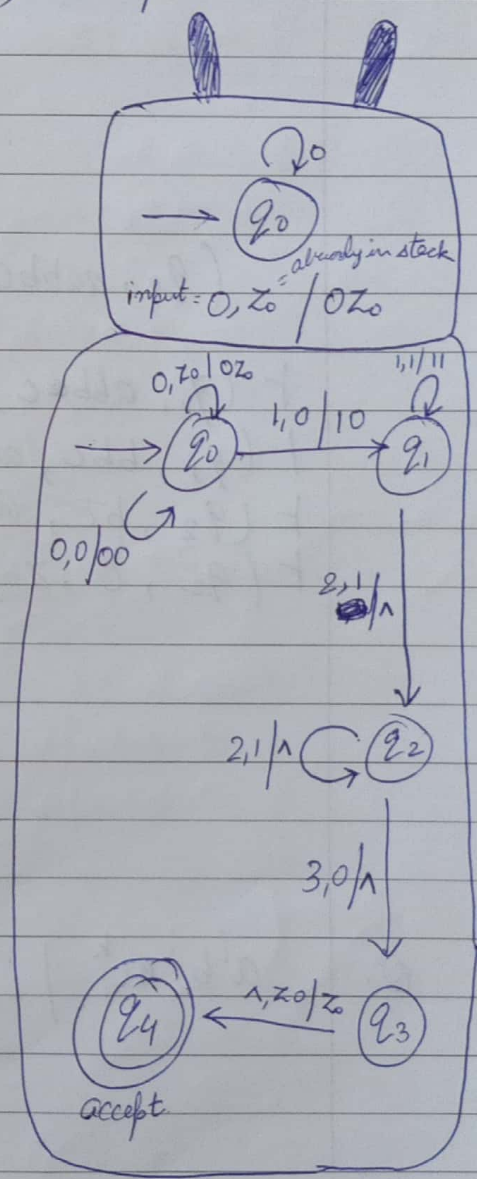
State	i/p	stack	move
q_0	a	Z_0	(q_0, aZ_0) (q_1, Z_0)
q_0	a	a	(q_0, aa) (q_1, a)
q_0	b	Z_0	(q_0, bZ_0) (q_1, Z_0)
q_0	b	b	(q_0, bb) (q_1, b)
q_0	a	b	(q_0, ab) (q_1, b)
q_0	b	a	(q_0, ba) (q_1, a)
q_0	$\wedge$	Z_0	(q, Z_0)
q_0	a	Z_0	(q_1, a)
q_0	b	Z_0	(q_1, b)
q_1	a	a	$(q_1, \wedge)$
q_1	b	b	$(q_1, \wedge)$
q_1	$\wedge$	Z_0	$(q_2, Z_0) \longrightarrow$ Accept.

Q. PDA for more no. of a's the b's.

State	i/p	stack	Move
q_0	a	Z_0	(q_1, Z_0)
q_0	b	Z_0	(q_0, bZ_0)
q_0	a	b	$(q_0, \wedge)$
q_0	b	b	(q_0, bb)
q_1	a	Z_0	(q_1, aZ_0)
q_1	a	a	(q_1, aa)
q_1	b	a	$(q_1, \wedge)$

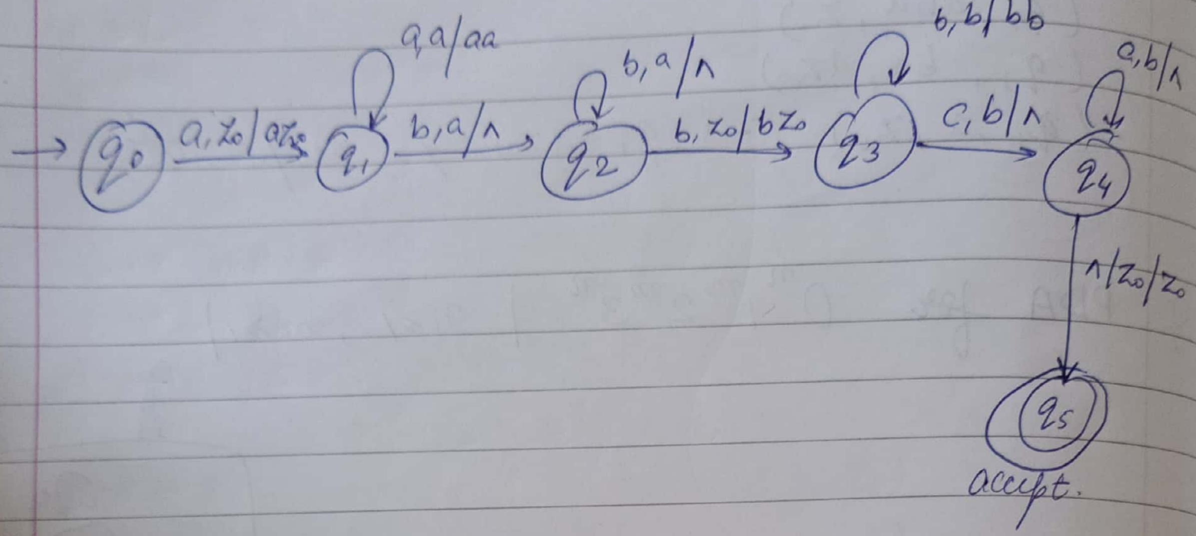
$(q_0, ababa, Z_0)$
$(q_1, ababa, Z_0)$
$(q_1, baba, aZ_0)$
(q_1, aba, Z_0)
(q_1, ba, aZ_0)
$(q_1, a, Z_0) \rightarrow (q_1, aZ_0) = q_2$ accept state.

Q. PDA for $0^n 1^m 2^m 3^n \mid n \geq 1, m \geq 1$



Q. $a^n \; b^{n+m} \; c^m \qquad n,m \geq 1$

$a^n b^n b^m c^m$



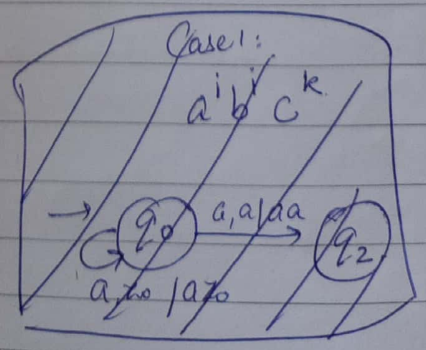
$(q_0, aabbc, Z_0)$

$\vdash (q_1, abbc, aZ_0)$
$\vdash (q_1, bbc, aaZ_0)$
$\vdash (q_2, bc, aZ_0)$
$\vdash (q_2, c, Z_0) \times$

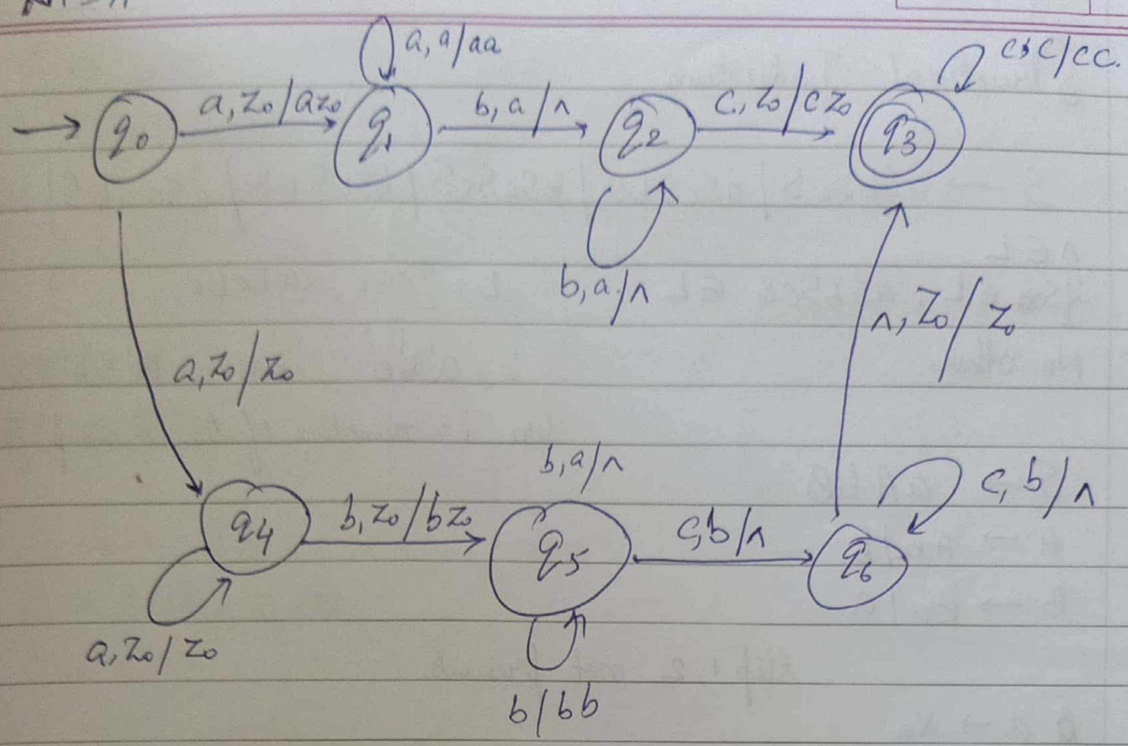
$(q_0, aabbbbcc, Z_0)$

$\vdash (q_1, abbbbcc, aZ_0)$
$\vdash (q_1, bbbbcc, aaZ_0)$
$\vdash (q_2, bbbcc, aZ_0)$
$\vdash (q_2, bbcc, Z_0)$
$\vdash (q_3, bcc, bZ_0)$
$\vdash (q_3, cc, bbZ_0)$
$\vdash (q_4, c, bZ_0)$
$\vdash (q_4, \wedge, Z_0)$ - Accept
q_5 = accepted.

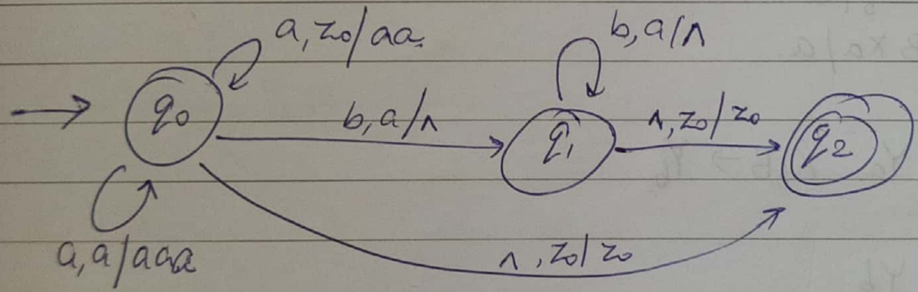
Q. $a^i b^j c^k \mid i,j,k \geq 1$ & $j=i$ or $j=k$.



NPDA



Q. $a^n b^{2n} / n \geq 0$



(q_0, abb, Z_0)

$\vdash (q_0, bb, aaZ_0)$

$\vdash (q_1, b, aZ_0)$

$\vdash (q_1, \Lambda, Z_0)$

q_2 - Accepted

Page No.:
Date:

Tut-6

Q3. Structural Induction

$S \to aSbScS \mid aScSbS \mid bSaScS \mid bScSaS \mid cSaSbS \mid cSbSaS$

1. $\Lambda \in L$
2. if $S \in L$, $aSbScS \in L$
3. No other.

$L = \{abc, aabcbc \ldots\}$

$k = a^i b^i c^i$ $\quad k+1 = a^i S b^i S c^i$

Here i = number of time we perform the

Q4.

1. $S \to aAbB$

$A \to Ab \mid b$

$B \to Ba \mid a$

Step 1, 2 not present.

$a \to X_a$

$b \to X_b$

Step 3.

$S \to X_a A X_b B$

$A \to A X_b \mid b$

$B \to B X_a \mid a$.

$X_a A \to Y_a$ $\quad X_b B \to Y_b$

$S \to Y_a Y_b$

$A \to A X_b \mid b$

$B \to B X_a \mid a$.

2. $S \to aA \mid bB$

$A \to bAA \mid a$

$B \to BBa \mid b$

$X_a = a$

$X_b = b$.

$S \to X_a A \mid X_b B$

$A \to X_b AA \mid a$ $\quad B \to BBX_b \mid b$

3. $S \to aAC$

$A \to aB \mid bAB$

$B \to b$

$C \to c$

$X_a \to a$

$X_b \to b$

$S \to X_a A C$

$A \to X_a B \mid X_b A B$

$B \to b$

$C \to c$

$X_a A \to Y_a$

$X_b A \to Y_b$

$S \to Y_a C$

$A \to X_a B \mid Y_b B$

$B \to b$

$C \to c.$

Page No.:
Date:

TuT-7

Ambiguous and Non-Ambiguous

Q. $S \to SS|a|b$ Ambiguous Eg - String: aba

$S \to aS|bS|a|b$ Unambiguous

Q. $S \to S+S|S*S|a$ Ambiguous

$S \to S+T|T$
$T \to T*F|F$
$F \to S|a$
Unambiguous

Q6.

1.

$S \to ABC|0$
$A \to 1$
$B \to C|0$
$C \to D$
$D \to E$
$E \to 2$

$S \to ABC|0$
$A \to 1$
$B \to 2|0$
$C \to 2$
$D \to 2$
$E \to 2$

2.

$S \to ABCD|0$
$A \to BC|1$
$B \to C$
$C \to D$
$D \to d$

$S \to ABCD|0$

Q.

$S \to ABA$
$A \to aA|\wedge$
$B \to abB|\wedge$
Ambiguous.

$S \to ABA|X$
$A \to aA|\wedge$
$B \to bB|b$
$X \to aX|\wedge$
Unambiguous

Q. $S \to A/B$
$A \to aAb/ab$
$B \to abB/\wedge$
Ambiguous

$S \to A/B$
$A \to aAb/ab$
$B \to abB/abab$
Unambiguous

Q. $S \to aSb \mid aaSb \mid \wedge$
Ambiguous

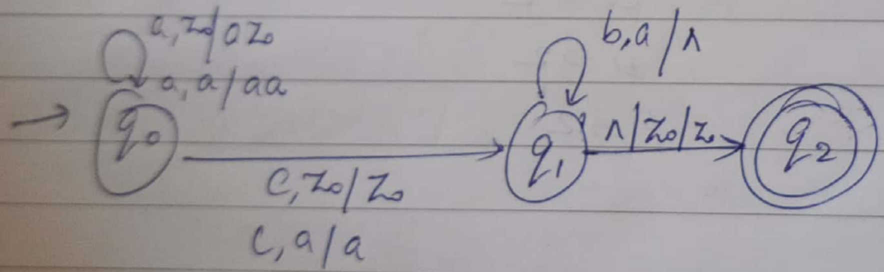
~~S → aXb / ...~~

$S \to X/Y/Z$
$X \to aXb/\wedge$
$Y \to aaYb/\wedge$
$Z \to aaabb/\wedge$

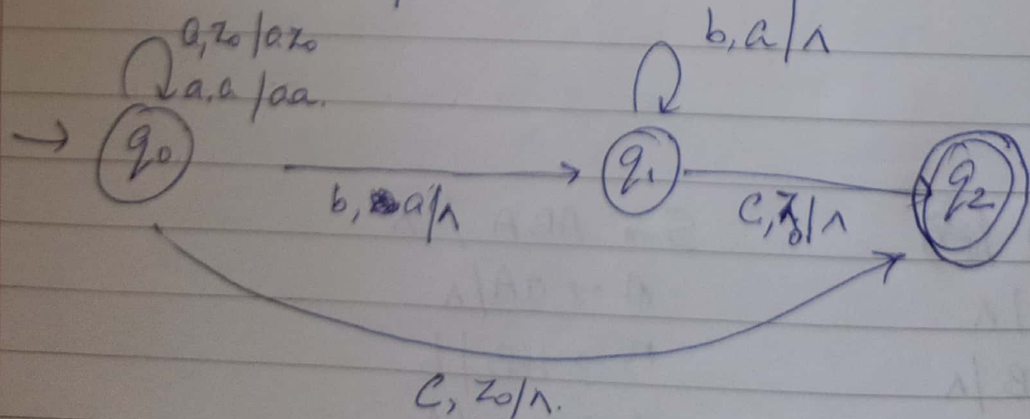
TUT-7

Design PDA.

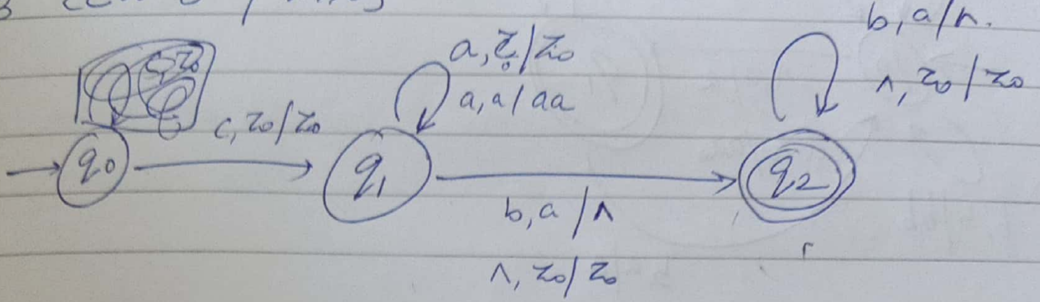
1). $L_1 = \{a^m c b^m \mid m \geq 0\}$



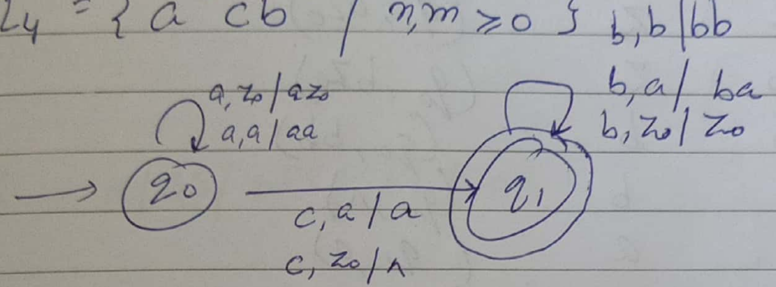
2) $L_2 = \{a^m b^m c \mid m \geq 0\}$



3). $L_3 = \{ca^m b^m / m \geq 0\}$

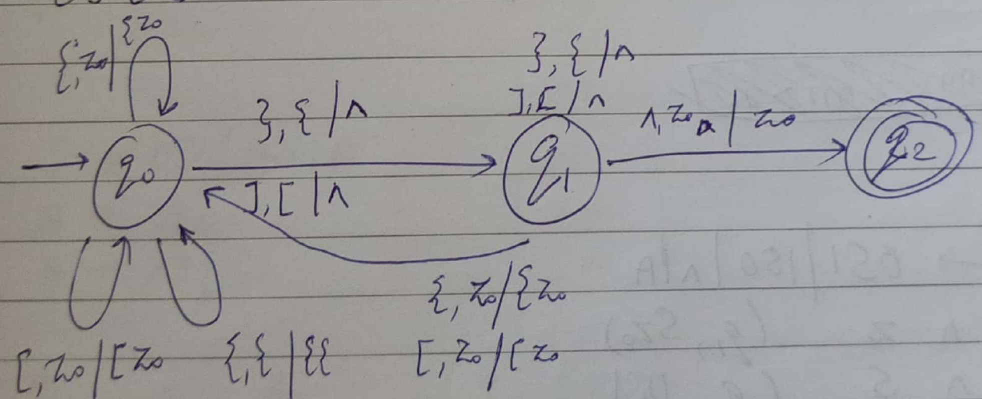


4). $L_4 = \{a^n c b^m / n,m \geq 0\}$



5). {}, [ ] $S \rightarrow \{S\} \mid [S] \mid SS \mid \Lambda$

{ } [ ] { }



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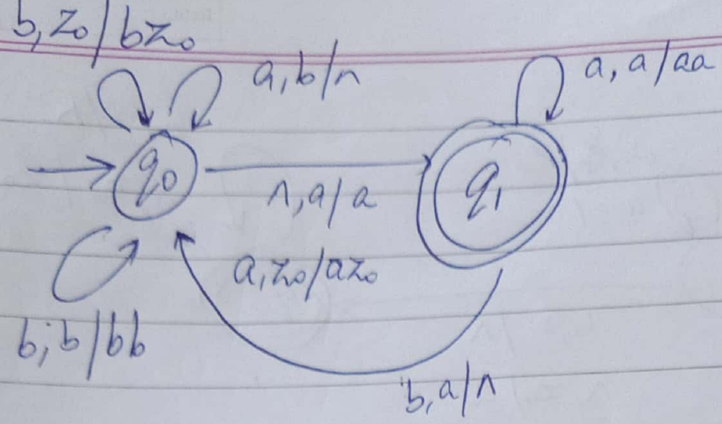
Q.



q_0	a	Z_0	(q_1, aZ_0)
q_0	b	Z_0	(q_0, bZ_0)
q_0	b	b	(q_0, bb)
q_0	a	b	$(q_0, \wedge)$
q_0	$\wedge$	a	(q_1, a)
q_1	a	a	(q_1, aa)
q_1	b	a	$(q_0, \wedge)$

more a's than b's. $a > b$

$S \rightarrow 0S1 \mid 1S0 \mid \wedge \mid A$

q_0	$\wedge$	Z_0	(q_1, SZ_0)
q_1	$\wedge$	S	$(q_1, 0S1)$
			$(q_1, 1S0)$
			$(q_1, \wedge)$

Q1. CFG to PDA

1. for each Non-terminal A, includes transition $\delta(q, \wedge, A) \rightarrow \{q, \alpha\}$
$/ A \rightarrow \alpha$ is in (G)

2. for each terminal a, include a transition $\delta(q, a, a) \rightarrow (q, \wedge)$.

$S \rightarrow a \mid aS \mid bSS \mid SSb \mid SbS$

q_0	$\wedge$	Z_0	(q_1, SZ_0)
q_1	$\wedge$	S	$(q_1, a)(q, aS)(q_1, bSS)(q_1, SSb)(q, SbS)$
q_1	a	a	$(q_1, \wedge)$
q_1	b	b	$(q_1, \wedge)$
q_1	$\wedge$	Z_0	(q_2, Z_0) Accept.

Q. $S \rightarrow 0S0 \mid 1S1 \mid A$
$A \rightarrow 2BB$
$B \rightarrow 23 \mid 31$

q_0	$\wedge$	Z_0	(q_1, SZ_0)
q_1	$\wedge$	S	$(q_1, 0S0)(q_1, 1S1)(q_1, A)$
q_1	$\wedge$	A	$(q_1, 2BB)$
q_1	$\wedge$	B	$(q_1, 23)(q_1, 31)$
q_1	0/1	0/1	$(q_1, \wedge)$
	3/2	3/2	$(q_1, \wedge)$
q_1	$\wedge$	Z_0	(q_2, Z_0) Accept state.

Derive - ~~22~~ 22331
$S \rightarrow A$
$\Rightarrow 2BB$
$\Rightarrow 22331$

Q. Design PDA for

$S \rightarrow bX \mid aY$
$X \rightarrow bXX \mid aS \mid a$
$Y \rightarrow aYY \mid bS \mid b$

q_0	$\wedge$	Z_0	(q_1, SZ_0)
q_1	$\wedge$	X	(q_1, bXX) (q_1, aS), (q_1, a)
q_1	$\wedge$	Y	(q_1, aYY) (q_1, bS) (q_1, b).
q_1	$\wedge$	S	(q_1, bX) (q_1, aY)
q_1	a	a	$(q_1, \wedge)$
q_1	b	b	$(q_1, \wedge)$.
q_1	$\wedge$	Z_0	(q_2, Z_0) Accept.

Tut-7

Q2. $S \rightarrow ABCD$
$A \rightarrow a$
$B \rightarrow C \mid b$
$C \rightarrow D$
$D - c$

$S \rightarrow ABCD$
$A \rightarrow a$
$B \rightarrow C \mid b$
$C \rightarrow c$
$D \rightarrow c$

$S \rightarrow ABCD$
$A \rightarrow a$
$B \rightarrow c \mid b$
$C \rightarrow c$
$D \rightarrow c$

Q3.

1. $S \rightarrow ABC \mid A0A$
$A \rightarrow 0A \mid B0C \mid 000 \mid B$
$C \rightarrow CA \mid AC$
$D \rightarrow \wedge$

2. $S \rightarrow AAA \mid B$
$A \rightarrow 0A \mid B$
$B \rightarrow \wedge$