

1. Answer the questions based on the given CFG:

S → aaBB | aCBB
B → b | ε
C → AB
A → a | ε

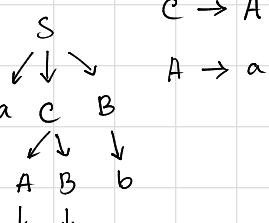
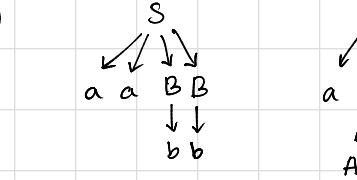
- a) With the help of Parse Tree show that the CFG is ambiguous for the string 'abb'.
b) Modify the CFG to remove the ambiguity for the said string.

b) $S \rightarrow a a B B \mid a C B B$

$B \rightarrow b \mid \epsilon$

$C \rightarrow A B$

$A \rightarrow a \mid \epsilon$



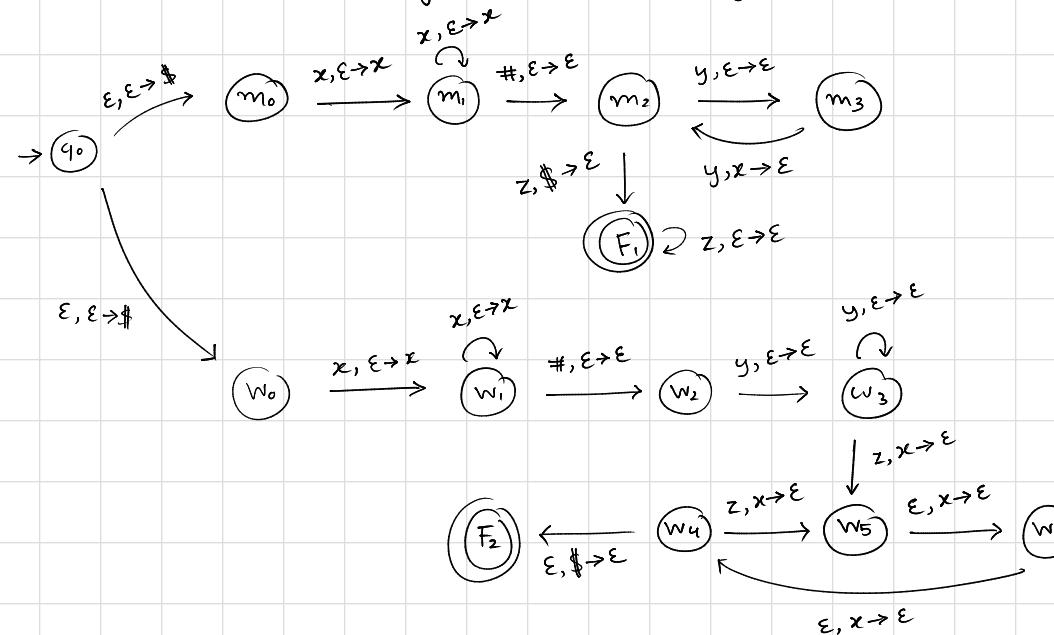
4. Draw the Push Down Automata (PDA) for the following languages:

a) $L = \{ x^m \# y^n z^w \mid m = n/2 \text{ or } w = m/3 \text{ and } m, n, w > 0 \}$

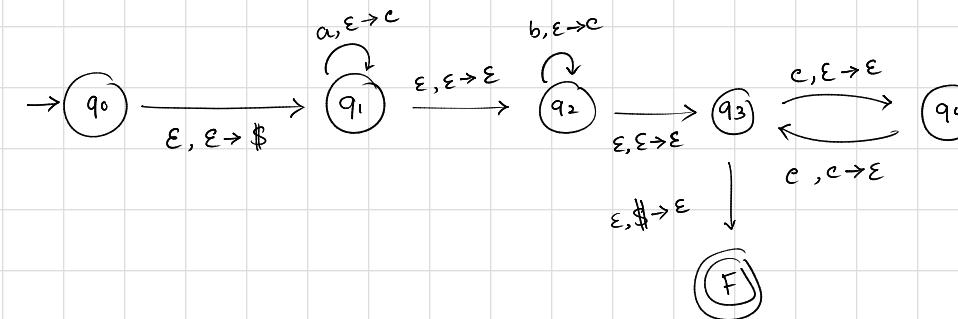
b) $L = \{ a^i b^j c^k \mid i + j = 2k \text{ and } i, j, k \geq 0 \}$

a) $n = 2m \text{ or } m = 3w$

two machines $x^m \# y^{2m} z^w$ and $x^{3w} \# y^n z^w$



b) $a^i b^j c^k \quad i+j=2k \quad i, j, k \geq 0$



2. Design CFGs that generate the following languages:

a) $L = \{ a^n b^m c^m d^n \mid n, m \geq 1 \text{ and } \Sigma = \{a, b, c, d\} \}$

b) $L = \{ w w^R \mid w \in \{a, b\}^+ \}$

c) $L = \{ w \in \{a, b\}^* \mid w \text{ contains at least three } 1s \}$

3. Showing all necessary steps, convert the following CFGs into their equivalent Chomsky Normal Form (CNF).

a) $S \rightarrow ABC \mid BaB$
 $A \rightarrow aA \mid BaC \mid aaa$
 $C \rightarrow bBb \mid a \mid D$
 $D \rightarrow \epsilon$

a) new init var and non-terminals

$S' \rightarrow S$

$S \rightarrow ABC \mid BaB$

$A \rightarrow aA \mid BaC \mid aaa$

$C \rightarrow bBb \mid a \mid D$

$D \rightarrow \epsilon$

$X \rightarrow a$

$Y \rightarrow b$

removing ϵ

$S' \rightarrow S$

$S \rightarrow ABC \mid BaB \mid AB$

$A \rightarrow aA \mid BaC \mid aaa \mid Ba$

$C \rightarrow bBb \mid a$

$X \rightarrow a$

$Y \rightarrow b$

b) $S \rightarrow BAC \mid B$
 $B \rightarrow 0B1 \mid 01$
 $A \rightarrow aAb \mid \epsilon$
 $C \rightarrow Bc$

$S' \rightarrow S$

$S \rightarrow BAC \mid B$

$B \rightarrow 0B1 \mid 01$

$A \rightarrow aAb \mid \epsilon$

$C \rightarrow Bc$

$S' \rightarrow S$

$S \rightarrow BAC \mid BC \mid B$

$B \rightarrow MBN \mid MN$

$A \rightarrow XAY \mid XY$

$C \rightarrow BZ$

$X \rightarrow a, Y \rightarrow b, Z \rightarrow c$

$M \rightarrow O, N \rightarrow I$

$P \rightarrow AC, Q \rightarrow BN, R \rightarrow AY$

replace terminals

$S' \rightarrow S$

$S \rightarrow ABC \mid BXB \mid AB$

$A \rightarrow XA \mid BXc \mid XXX \mid BX$

$C \rightarrow YBY \mid X$

$X \rightarrow a$

$Y \rightarrow b$

remove groupings of > 2

$S' \rightarrow S$

$S \rightarrow MC \mid NB \mid AB$

$A \rightarrow XA \mid NC \mid OX \mid BX$

$C \rightarrow YP \mid X$

$X \rightarrow a \quad M \rightarrow AB \quad N \rightarrow BX$

$Y \rightarrow b \quad O \rightarrow XX \quad P \rightarrow BY$

remove single non-terminals

$S' \rightarrow MC \mid NB \mid AB$

$S \rightarrow MC \mid NB \mid AB$

$A \rightarrow XA \mid NC \mid OX \mid BX$

$C \rightarrow YP \mid a$

$X \rightarrow a \quad M \rightarrow AB \quad N \rightarrow BX$

$Y \rightarrow b \quad O \rightarrow XX \quad P \rightarrow BY$

$S' \rightarrow BP \mid BC \mid B$

$S \rightarrow BP \mid BC \mid MQ \mid MN$

$B \rightarrow MQ \mid MN$

$A \rightarrow XR \mid XY$

$C \rightarrow BZ$

$X \rightarrow a, Y \rightarrow b, Z \rightarrow c$

$M \rightarrow O, N \rightarrow I$

$P \rightarrow AC, Q \rightarrow BN, R \rightarrow AY$

5. Draw a Turing Machine for the following language and show the Tape Traversal to validate the given input:

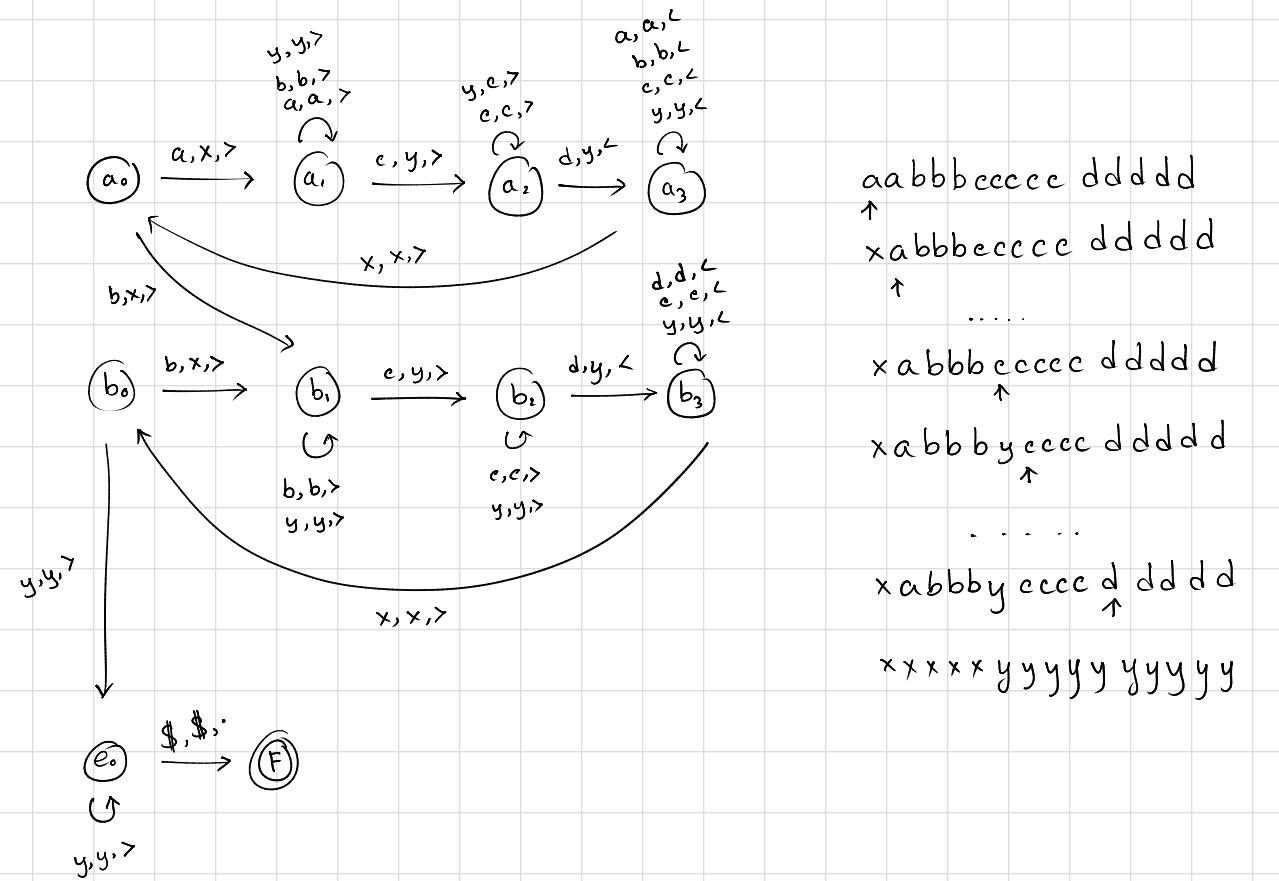
$$L = \{ a^p b^r c^q d^x \mid r = x-p \text{ and } q = p+r \text{ and } p, q, r, x \geq 1 \}$$

Input String: aabbbeccccddddd

$$a^p b^r c^{p+r} d^{p+r}$$

$$x = p+r$$

$$q = p+r$$



Tape Traversal:

Initial tape: aabbbeccccddddd

After a_1 : xabbbeccccddddd

After a_2 : xabbbccccddddd

After a_3 : xabbbbyccccddddd

After b_1 : xabbbbyccccddddd

After b_2 : xabbbbyccccddddd

After b_3 : xabbbbyccccddddd

Final tape: xxxxxyyyyyyyyy