Question bank (Unit 3)

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4) $S \rightarrow S+S \mid S*S \mid 4$

$V \rightarrow \{S\}$

$T \rightarrow \{+, *, 4\}$

$P \rightarrow \{S+S,\ S*S,\ 4\}$

$S \rightarrow S$

2) a) ab^* $L = \{a, ab, abb, abbb, \ldots\}$

$S \rightarrow a \mid Sb$

b) a^*b^* $L = \{\varepsilon, ab, aab, abb, aabb, \ldots\}$

$S \rightarrow aSb \mid \varepsilon$

c) $L = \{(baa + abb)^*$

$L = \{\varepsilon, baa, abb, baaabb, baabaa, abbabb, \ldots\}$

$S \rightarrow \varepsilon \mid A$

$A \rightarrow \varepsilon \mid baaA \mid abbA$

OR

$S \rightarrow \varepsilon \mid baaS \mid abbS$

d) $L = \{a^i b^j c^k \mid i = j+k\}$

$L = \{\varepsilon, aabc, aaabbc, aaabcc, aaaabbcc, \ldots\}$

$S \rightarrow aSb \mid aSc \mid \varepsilon X$

$X \rightarrow aXb \mid \varepsilon$

e) $(a+b)^*\ bbb\ (a+b)^*$

A A

$L = \{bbb, abbb, bbbb, bbba, abbba, \ldots\}$

$S \rightarrow AbbbA$

$A \rightarrow \varepsilon \mid aA \mid bA$

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

$L = \{\varepsilon, ac, bc, aabc, aacc, aabb, \ldots\}$

$S \rightarrow aSc \mid X$

$X \rightarrow \varepsilon \mid bXc$

g) $L = \{a^i b^j c^k \mid i+j = k \mid i,j \geq 1\}$

$L = \{abcc, aabccc, abbccc, \ldots\}$

$S \rightarrow aSc \mid aXc$

$X \rightarrow bXc \mid bc$

h) $(a+b)^*$

$G = (S, \{a,b\}, \{S \rightarrow aSb \mid ab\}, S)$

3) ⇓ CFL

$L = \{ab, aabb, aaabbb, \ldots\}$

$CFL \rightarrow (a^+ b^+)$

$L = \{a^n b^n \mid n \geq 1\}$

4) $S \rightarrow XY$

$X \rightarrow aX \mid bX \mid a$

$Y \rightarrow Ya \mid Yb \mid a$

$L = \{aa, aaa, aaaa, baa, baab, abaaab, aabbaab, aab, abaa\}$

$(a+b)^*a.\ (a+ab)$

$CFL \rightarrow L = \{(a,b)^*,$ ends with aa or aab$\}$

5) i) $(011+1)^*(01)^*$

A B

$L = \{\varepsilon, 011, 1, 01, 01101, 101, 01101101, \ldots\}$

$S \rightarrow AB$

$A \rightarrow 011A \mid 1A \mid \varepsilon$

$B \rightarrow 01B \mid \varepsilon$

ii) $0^i 1^{i+k} 0^k$ where $i, k >= 0$

A B

$L = \{\varepsilon, 01, 10, 0110, 0011, 1100, 011100, \ldots\}$

$S \rightarrow AB$

$A \rightarrow 01 \mid 0A1 \mid \varepsilon$

$B \rightarrow 10 \mid 1B0 \mid \varepsilon$

6) $L = \{aa, a, b, bb, abba, baab, bab, aba, \ldots\}$

$S \rightarrow \varepsilon \mid asa \mid bsb \mid a \mid b$

7) $\Sigma = \{a, b\}$

a) all strings having at least two a's

$L = \{aa, baa, aabb, aba, abab, aabb, bbaa \ldots\}$

$S \rightarrow aA \mid bS$

$A \rightarrow aA \mid bA$

$B \rightarrow aB \mid bB \mid \varepsilon$

} δ

$G = (\{S, A, B\}, \{a, b, \varepsilon\}, \delta, S)$

b) $L = \{\varepsilon, a, b, aa, ba, ab, aab, abaab, abab, baba, baab, \ldots\}$

$S \rightarrow aS \mid bA \mid \varepsilon$

$A \rightarrow aS \mid \varepsilon$

8) $\Sigma = \{0, 1\}^*$

i) $L = \{00, 001, 10000, 1100, 0011, 100100, \ldots\}$

$S \rightarrow \cancel{00} \mid \cancel{A00} \mid \cancel{00A}$ A 00A

$A \rightarrow 0A \mid 1A \mid \varepsilon$

ii) $L = \{0, 00, 10, 0010, 010, 110, \ldots\}$

$S \rightarrow 0S \mid 1S \mid \varepsilon 0$

iii) $L = \{\varepsilon, 0, 00, 0011, 0101, 1100, 1111, 11, 10111, 011011, \ldots\}$

$S \rightarrow \varepsilon \mid 0S \mid 1A$

$A \rightarrow 1S \mid 0A$

9) $L = \{WcW^T \mid W \in \{a, b\}^*$ & W^T is the reverse of $W\}$

$S \rightarrow asa \mid bsb \mid c$

10) $L = \{a^n b^n \mid n >= 0\}$

$S \rightarrow asb \mid \varepsilon$

11) CFG

i) $L = \{ a^n c^m b^n \mid n \geq 0 \mid m >= 1 \}$

$L = \{ c, acb, accb, aacbb, ecc, \ldots \}$

$S \rightarrow asb \mid axb \mid x$

$X \rightarrow cx \mid c$

ii) $L = \{ a^i b^j c^k \mid i = j+k \quad i,j,k >= 1 \}$

$L = \{ aabc, aaabbc, aaabcc, aaaaabbccc, aaaabbcc, aaabbc, \ldots \}$

$S \rightarrow aXc \mid asc \mid ab$

$X \rightarrow axb \mid ab$

iii) $L = \{ a^i b^j c^k \mid j = i+k \quad i,j,k \geq 1 \}$

$L = \{ abbc, abbc, abbbcc, aaabbc, \ldots \}$

$S \rightarrow AB$

$A \rightarrow aAb \mid ab$

$B \rightarrow bBc \mid bc$

12) $L = \{ a^n b^n c^m d^m \mid n,m >= 1 \} \cup \{ a^m b^n c^n d^m \mid n,m >= 1 \}$

$L = \{ abcd, aabbcd, abccdd, aabbccdd, \ldots \}$

$\cup$

$L = \{ abcd, aabcdd, abbccd, aabbccdd, \ldots \}$

$S \rightarrow S_1 \mid S_2$

$S_1 \rightarrow AB$

$A \rightarrow aAb \mid ab$

$B \rightarrow cBd \mid cd$

$S_2 \rightarrow aS_2d \mid aTd$

$T \rightarrow bTc \mid bc$

13) $L = \{ a^{2n} b^n \mid n >= 1 \}$

$L = \{ aab, aaaabb, \ldots \}$

$S \rightarrow aasb \mid aab$

14) $L = \{ (), ()(), (()), (()()), \ldots \}$

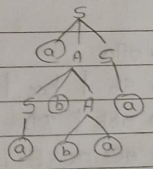
$S \rightarrow SS \mid (S) \mid \varepsilon$

16) "aabbaa"

$S \rightarrow aAS \mid a$

$A \rightarrow SbA \mid SS \mid ba$

Left :-

$S \rightarrow aAS$ 

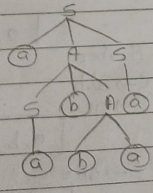
$\rightarrow asbAS$ $(A \rightarrow SbA)$

$\rightarrow aabAS$ $(S \rightarrow a)$

$\rightarrow aabbaS$ $(A \rightarrow ba)$

$\rightarrow aabbaa$ $(S \rightarrow a)$

Right :-

$S \rightarrow aAS$ 

$\rightarrow aAa$ $(S \rightarrow a)$

$\rightarrow asbAa$ $(A \rightarrow SbA)$

$\rightarrow asbbaa$ $(A \rightarrow ba)$

$\rightarrow aabbaa$ $(S \rightarrow a)$

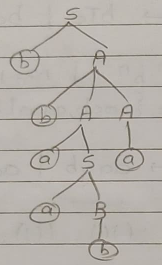
17)

$S \rightarrow aB \mid bA$
$A \rightarrow a \mid aS \mid bAA$
$B \rightarrow b \mid bS \mid aBB$

"bbaaba"

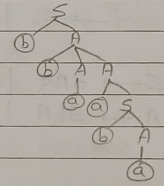
Right :-

$S \rightarrow bA$ (A → bAA)
$\rightarrow bbAA$ (A → a)
$\rightarrow bbAa$ (A → as)
$\rightarrow bbaSa$ (S → aB)
$\rightarrow bbaaBa$ (B → b)
$\rightarrow bbaaba$



Left :-

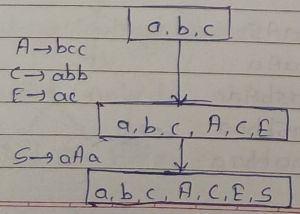
$S \rightarrow bA$ (A → bAA)
$\rightarrow bbAA$ (A → a)
$\rightarrow bbaA$ (A → as)
$\rightarrow bbaaS$ (S → bA)
$\rightarrow bbaabA$ (A → a)
$\rightarrow bbaaba$



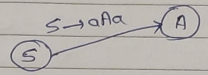
24)

$S \rightarrow aAa$
$A \rightarrow Sb \mid bcc \mid DaA$
$C \rightarrow abb \mid DD$
$E \rightarrow aE \mid ac$
$D \rightarrow aDa$

→



D is non-generating.



C, D, E is non-reachable

23) $S \rightarrow oAo \mid 1B1 \mid BB$
$A \rightarrow C$
$B \rightarrow S \mid A$
$C \rightarrow S \mid \varepsilon$

→ ε - removal. :-
$S \rightarrow oo$
$S \rightarrow 11$
$S \rightarrow B$

Unit production :-
$S \rightarrow oAo \mid 1B1 \mid BB \mid oo \mid 11 \mid B$
$A \rightarrow C$
$B \rightarrow S \mid A$
$C \rightarrow S$

Now,
$S \rightarrow oAo \mid 1B1 \mid BB \mid oo \mid 11$

25)

$S \rightarrow ABA$
$A \rightarrow aA \mid \varepsilon$
$B \rightarrow bB \mid \varepsilon$

→ ε - removal :-
$S \rightarrow AB$
$S \rightarrow BA$
$S \rightarrow B$

$S \rightarrow AA$
$S \rightarrow A$
$A \rightarrow a$
$B \rightarrow b$

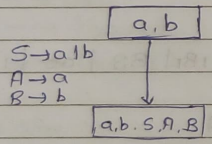
Unit production :

$S \rightarrow ABA \mid AB \mid BA \mid B \mid AA \mid A$
$A \rightarrow aA \mid a$
$B \rightarrow bB \mid b$

Now,

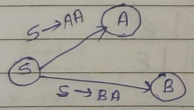
$S \rightarrow ABA \mid AB \mid BA \mid bB \mid AA \mid aA \mid a \mid b$
$A \rightarrow aA \mid a$
$B \rightarrow bB \mid b$

Non-generating :



all are generating

Non-Reachable :



all are reachable.

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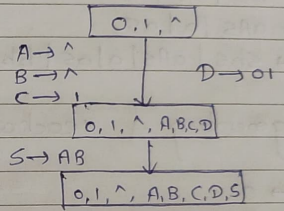
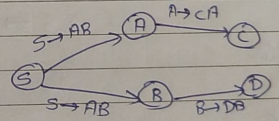
Grammar to CNF

$S \rightarrow AB$
$A \rightarrow CA \mid \wedge$
$B \rightarrow DB \mid \wedge$
$C \rightarrow 011 \mid 1$
$D \rightarrow 01$

→ There is no ε-production, Unit production





all are generating & reachable.

Now, CNF Conversion.

Let,

$P \rightarrow 1$
$Q \rightarrow 0$

$D \rightarrow QP$
$C \rightarrow DP$

Now, final rules.

$S \rightarrow AB$
$A \rightarrow CA \mid \wedge$
$B \rightarrow DB \mid \wedge$
$P \rightarrow 1$
$Q \rightarrow 0$
$C \rightarrow DP \mid 1$
$D \rightarrow QP$

29)

$S \rightarrow ASB$
$A \rightarrow aAS \mid a \mid \varepsilon$
$B \rightarrow SbS \mid A \mid bb$

→ ε- removale.

$S \rightarrow SB \mid AS$
$A \rightarrow aS$
$S \rightarrow S$

Unit - production

$S \rightarrow ASB \mid SB \mid AS$
$A \rightarrow aAS \mid a \mid aS$
$B \rightarrow SbS \mid aAS \mid a \mid aS \mid bb$

all are generating & reachable.

Let,

$P \rightarrow a$
$Q \rightarrow b$

$S \rightarrow XB \mid SB \mid AS$
$A \rightarrow PX \mid a \mid PS$
$B \rightarrow a \mid PX \mid PS \mid QQ \mid YS$

$B \rightarrow QQ$
$X \rightarrow AS$
$Y \rightarrow SQ$

31)

$S \rightarrow ABAb \mid ab$
$A \rightarrow a \mid b$
$B \rightarrow ABA \mid a$

→ GNF Conversion

Let,

$P \rightarrow b$

Now, ~~$Q \rightarrow b$~~

~~$T \rightarrow AB$~~

$S \rightarrow aBAP \mid bBAP \mid aP$
$A \rightarrow a \mid b$
$B \rightarrow aBA \mid bBA \mid a$

33)

$S \rightarrow ABA \mid AB \mid BA \mid AA \mid aA \mid a \mid bB \mid b$

$A \rightarrow aA \mid a$

$B \rightarrow bB \mid b$

Now,

GNF :-

$S \rightarrow aBA \mid aB \mid bA \mid aA \mid a \mid bB \mid b$

$A \rightarrow aA \mid a$

$B \rightarrow bB \mid b$

34)

$S \rightarrow aSa \mid bSb \mid a \mid b \mid aa \mid bb \mid AB \mid BA \mid AA \mid BB \mid$ ~~ε~~

$aA \mid$ ~~ε~~

$A \rightarrow aA \mid a$

$B \rightarrow bB \mid b$

Now,

CNF :-

let, $P \rightarrow a$ $\quad T \rightarrow SP$

$Q \rightarrow b$ $\quad U \rightarrow SQ$

$S \rightarrow PT \mid QU \mid a \mid b \mid PP \mid QQ \mid AB \mid BA \mid AA \mid QB \mid PA$

$A \rightarrow PA \mid a$

$B \rightarrow QB \mid b$

35)

$S \rightarrow 0P \mid 0 \mid 1Q \mid 1 \mid PQ \mid QP \mid PP$

$P \rightarrow 0P \mid 0$

$Q \rightarrow 1Q \mid 1$

Now,

CNF :-

$S \rightarrow PP \mid QQ \mid PQ \mid QP \mid 0 \mid 1$

$P \rightarrow PP \mid 0$

$Q \rightarrow QQ \mid 1$

36)

$S \rightarrow aAa \mid bBb \mid aa \mid bb$

$A \rightarrow CDE \mid DE \mid a$

$B \rightarrow CDE \mid DE \mid b$

$D \rightarrow CDE \mid DE \mid a \mid b \mid ab$

Now,

GNF

Let, $P \rightarrow a$

$Q \rightarrow b$

$S \rightarrow aAP \mid bBQ \mid aP \mid bQ$

$A \rightarrow$