United International University

Assignment 02

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Section: H

Course: Theory of Computation (CSE 2233)
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1. $S \to YXZ \mid Y$
$Y \to 0Y1 \mid 01$
$X \to aXb \mid \epsilon$
$Z \to BZ$

i) no need

ii) remove null

$X \to \epsilon$

$S \to YXZ \mid Y \mid YZ$
$Y \to 0Y1 \mid 01$
$X \to aXb \mid ab$
$Z \to BZ$

iii) remove unit production

$S \to Y$

$S \to YXZ \mid 0Y1 \mid 01 \mid YZ$
$Y \to 0Y1 \mid 01$
$X \to aXb \mid ab$
$Z \to BZ$

iv, v) $A_1 \to a$ $\quad 0_0 \to 0$
$B_1 \to b$ $\quad 0_1 \to 1$
$C_1 \to z$
$P \to YX$ $\quad Q \to 0_0 Y$
$R \to A_1 X$

$S \to PZ \mid Q0_1 \mid 0_0 0_1 \mid YZ$
$Y \to Q0_1 \mid 0_0 0_1$
$X \to RB_1 \mid A_1 B_1$
$Z \to BC_1$

CNF.

2.

$S \to ASB$

$A \to aAS \mid a \mid \epsilon$

$B \to SbS \mid A \mid bb$

i) $S' \to S$

$S \to ASB$

$A \to aAS \mid a \mid \epsilon$

$B \to SbS \mid A \mid bb$

ii) $A \to \epsilon$

$S' \to S$

$S \to ASB \mid SB$

$A \to aAS \mid a \mid aS$

$B \to SbS \mid A \mid bb \mid \epsilon$

$B \to \epsilon$

$S' \to S$

$S \to ASB \mid SB \mid AS \mid S$

$A \to aAS \mid a \mid aS$

$B \to SbS \mid A \mid bb$

iii) for $S' \to S$, $S \to S$, $B \to A$

$S' \to ASB \mid SB \mid AS$

$S \to ASB \mid SB \mid AS$

$A \to aAS \mid a \mid aS$

$B \to SbS \mid aAS \mid a \mid aS \mid bb$

[P.T.O.]

iv, v)

$A_1 \to a \quad Y \to SB_1$

$X \to AS$

$B_1 \to b$

$S' \to XB \mid SB \mid AS$

$S \to XB \mid SB \mid AS$

$A \to A_1X \mid a \mid A_1S$

$B \to YS \mid A_1X \mid a \mid A_1S \mid B_1B_1$

(Ans).

3.

$S \to ASA \mid aB$

$A \to B \mid S$

$B \to b \mid \epsilon$

i) $S' \to S$

$S \to ASA \mid aB$

$A \to B \mid S$

$B \to b \mid \epsilon$

ii) null remove

$B \to \epsilon$:

$S' \to S$

$S \to ASA \mid aB \mid a$

$A \to B \mid S \mid \epsilon$

$B \to b$

$A \to \epsilon$:

$S' \to S$

$S \to ASA \mid aB \mid a \mid SA \mid AS \mid S$

$A \to B \mid S$

$B \to b$

(iii) for $A \to B, S \to S$

$S' \to ASA \mid aB \mid a \mid SA \mid AS$

$S \to ASA \mid aB \mid a \mid SA \mid AS$

$A \to b \mid ASA \mid aB \mid a \mid SA \mid AS$

$B \to b$

(iv, v)

$Y_1 \to a$

$X \to AS$

$S' \to XA \mid Y_1B \mid a \mid SA \mid AS$.

$S \to XA \mid Y_1B \mid a \mid SA \mid AS$

$A \to b \mid XA \mid Y_1B \mid a \mid SA \mid AS$

$B \to b$

(Ans).

4. $S \to S+S \mid S-S \mid (S) \mid T$

$T \to x \mid y \mid z \mid X$

$X \to X*X \mid X\%X \mid Y$

$Y \to 0 \mid 1$

Unambiguous:

$S' \to S$

$S \to S+S \mid S-S \mid (S) \mid T$ $\quad X \to X*X \mid X\%X \mid Y$

$T \to x \mid y \mid z \mid X$ $\quad Y \to 0 \mid 1$

ii) remove null

↳ none

iii) for $X \to Y$, $T \to X$, $S \to T$ and $S' \to S$

$S' \to S+S \mid S-S \mid (S) \mid x \mid y \mid z \mid X*X \mid X\%X \mid 0 \mid 1$

$S \to S+S \mid S-S \mid (S) \mid x \mid y \mid z \mid X*X \mid X\%X \mid 0 \mid 1$

$T \to x \mid y \mid z \mid X*X \mid X\%X \mid 0 \mid 1$

$X \to X*X \mid X\%X \mid 0 \mid 1$

$Y \to 0 \mid 1$

iv, v)

$A_1 \to +$
$A_2 \to -$
$A_3 \to *$
$A_4 \to \%$
$P \to S A_1$
$Q \to S A_2$

$B_1 \to ($
$B_2 \to)$
$X_1 \to x$
$Y_1 \to y$
$Z_1 \to z$
$R \to B_1 S$

$S \to X A_3$
$T \to X A_4$

$S' \to PS \mid QS \mid RB_2 \mid x_1 \mid Y_1 \mid Z_1 \mid SX \mid TX \mid 0 \mid 1$

$S \to PS \mid QS \mid RB_2 \mid x_1 \mid Y_1 \mid Z_1 \mid SX \mid TX \mid 0 \mid 1$

$T \to x \mid y \mid z \mid SX \mid TX \mid 0 \mid 1$

$X \to SX \mid TX \mid 0 \mid 1$

$Y \to 0 \mid 1$,

(Ans).

5.

$S \to ASB$

$A \to aAS \mid a \mid \epsilon$

$B \to SbS \mid A \mid bb$

i) $S' \to S$

$S \to ASB$

$A \to aAS \mid a \mid \epsilon$

$B \to SbS \mid A \mid bb$

ii) $A \to \epsilon$

$S' \to S$

$S \to ASB \mid SB$

$A \to aAS \mid a \mid aS$

$B \to SbS \mid A \mid bb \mid \epsilon$

$B \to \epsilon$

$S' \to S$

$S \to ASB \mid SB \mid AS \mid S$

$A \to aAS \mid a \mid aS$

$B \to SbS \mid A \mid bb$

iii) for $S' \to S$, $S \to S$, $B \to A$

$S' \to ASB \mid SB \mid AS$

$S \to ASB \mid SB \mid AS$

$A \to aAS \mid a \mid aS$

$B \to SbS \mid aAS \mid a \mid aS \mid bb$

iv, v) $A_1 \to a$ $\quad X \to AS$

$B_1 \to b$ $\quad Y \to SB_1$

$S' \to XB \mid SB \mid AS$

$S \to XB \mid SB \mid AS$

$A \to A_1X \mid a \mid A_1S$

$B \to YS \mid A_1X \mid a \mid A_1S \mid B_1B_1$

(Ans).

6. $S \to aSBcD \mid BC$

$A \to AbCd \mid a$

$B \to CBA \mid \epsilon$

$C \to c \mid \epsilon$

$D \to d$

i) $S' \to S$

$S \to aSBcD \mid BC$

$A \to AbCd \mid a$

$B \to CBA \mid \epsilon$

$C \to c \mid \epsilon$

$D \to d$

ii) remove null :-

$B \to \epsilon$

$S' \to S$

$S \to aSBcD \mid BC \mid aScD \mid C$

$A \to AbCd \mid a$

$B \to CBA \mid CA$

$C \to c \mid \epsilon$

$D \to d$

$C \to \epsilon$

$S' \to S$

$S \to aSBcD \mid BC \mid aScD \mid c \mid B \mid \epsilon$

$A \to AbCd \mid a \mid Abd$

$B \to CBA \mid CA \mid BA \mid A$

$C \to c$

$D \to d$

$S \to \epsilon$

$S' \to S$

$S \to aSBcD \mid BC \mid aScD \mid c \mid B \mid aBcD \mid acD$

$A \to AbCd \mid a \mid Abd$

$B \to CBA \mid CA \mid BA \mid A$

$C \to c \qquad D \to d$

iii) unit :

for $S' \to S$, $S \to B$, $S \to C$, $B \to C$

$S' \to aSBcD \mid BC \mid aScD \mid c \mid CBA \mid CA \mid BA \mid aBcD \mid acD$

$S \to aSBcD \mid BC \mid aScD \mid c \mid CBA \mid CA \mid BA$

$A \to Abcd \mid a \mid Abd$

$B \to CBA \mid CA \mid BA \mid aA$

$C \to c$

$D \to d$

iv, v)

$A_1 = a$ $\quad P \to A_1S$ $\quad T \to AB_1$

$B_1 \to b$ $\quad Q \to C_1D$ $\quad U \to CD_1$

$C_1 \to c$ $\quad R \to BQ$ $\quad V \to A_1B$

$D_1 \to d$ $\quad S \to BA$

$S \to PR \mid BC \mid PQ \mid c \mid CS \mid CA \mid BA \mid VQ \mid A_1Q$

$A \to TU \mid a \mid TD_1$

$B \to CS \mid CA \mid BA \mid aA$

$C \to c$

$D \to d$

(Ans).

7.

$S \to xP \mid yQ \mid y \mid RRz$

$P \to Qxx \mid xyR \mid \epsilon$

$Q \to yPPy \mid xy \mid zR$

$R \to x \mid y \mid PR \mid \epsilon$

i) right side occurrence:

↳ not needed

ii) remove null:

$\underline{P \to \epsilon}$

$S \to xP \mid yQ \mid y \mid RRz \mid x$

$P \to Qxx \mid xyR$

$Q \to yPPy \mid xy \mid zR \mid yPy \mid yy$

$R \to x \mid y \mid PR \mid \epsilon \mid R$

$\underline{R \to \epsilon}$

$S \to xP \mid yQ \mid y \mid RRz \mid x \mid Rz \mid z$

$P \to Qxx \mid xyR \mid xy$

$Q \to yPPy \mid xy \mid zR \mid yPy \mid yy \mid z$

$R \to x \mid y \mid PR \mid R \mid P$

iii) remove unit productions:

for $R \to R$, $R \to P$

$S \to xP \mid yQ \mid y \mid RRz \mid x \mid Rz \mid z$

$P \to Qxx \mid xyR \mid xy$

$Q \to yPPy \mid xy \mid zR \mid yPy \mid yy \mid z$

$R \to x \mid y \mid PR \mid Qxx \mid xyR \mid xy$

iv, v)

$X_1 \to x$ $\quad A \to RR$

$Y_1 \to y$ $\quad B \to QX_1$

$Z_1 \to z$ $\quad C \to X_1Y_1$

$D \to Y_1P$ $\quad E \to PY_1$

$S \to X_1P \mid Y_1Q \mid AZ_1 \mid RZ_1 \mid z \mid x \mid y$

$P \to BX_1 \mid CR \mid X_1Y_1$

$Q \to DE \mid X_1Y_1 \mid Z_1R \mid z \mid DY_1 \mid Y_1Y_1$

$R \to x \mid y \mid PR \mid BX_1 \mid CR \mid X_1Y_1$

End.

8.

$A \to 1 \mid B \mid CA \mid \epsilon$

$B \to 1BS \mid 0S0B \mid \epsilon$

$C \to x \mid y \mid A$

$S \to 1A1 \mid 0S \mid S \mid A1$

i) right side occurrence:

$A' \to A$

$A \to 1 \mid B \mid CA \mid \epsilon$

$B \to 1BS \mid 0S0B \mid \epsilon$

$C \to x \mid y \mid A$

$S \to 1A1 \mid 0S \mid S \mid A1$

ii) remove null:

1. $\underline{A \to \epsilon}$

$A' \to A \mid \epsilon$

$A \to 1 \mid B \mid CA \mid C$

$B \to 1BS \mid 0S0B \mid \epsilon$

$C \to x \mid y \mid A \mid \epsilon$

$S \to 1A1 \mid 0S \mid S \mid A1 \mid 11 \mid 1$

2. $\underline{B \to \epsilon}$

$A' \to A \mid \epsilon$

$A \to 1 \mid B \mid CA \mid C \mid \epsilon$

$B \to 1BS \mid 0S0B \mid 1S \mid 0S0$

$C \to x \mid y \mid A \mid \epsilon$

$S \to 1A1 \mid 0S \mid S \mid A1 \mid 11 \mid 1$

3. again $\underline{A \to \epsilon}$

$A' \to A \mid \epsilon$

$A \to 1 \mid B \mid CA \mid C \mid$

$B \to 1BS \mid 0S0B \mid 1S \mid 0S0$

$C \to x \mid y \mid A \mid \epsilon$

$S \to 1A1 \mid 0S \mid S \mid A1 \mid 11 \mid 1$

4. $\underline{C \to \epsilon}$

$A' \to A \mid \epsilon$

$A \to 1 \mid B \mid CA \mid C \mid A \mid \epsilon$

$B \to 1BS \mid 0S0B \mid 1S \mid 0S0$

$C \to x \mid y \mid A$

$S \to 1A1 \mid 0S \mid S \mid A1 \mid 11 \mid 1$

5. again $A \to \epsilon$

$A' \to A \mid \epsilon$
$A \to 1 \mid B \mid CA \mid C \mid A$
$B \to 1BS \mid 0S0B \mid 1S \mid 0S0$
$C \to x \mid y \mid A \mid \epsilon$
$S \to 1A1 \mid 0S \mid S \mid A1 \mid 11 \mid 1$

after omitting $A \to \epsilon$, $C \to \epsilon$

$A' \to A \mid \epsilon$
$A \to 1 \mid B \mid CA \mid C \mid A$
$B \to 1BS \mid 0S0B \mid 1S \mid 0S0$
$C \to x \mid y \mid A$
$S \to 1A1 \mid 0S \mid S \mid A1 \mid 11 \mid 1$

here,
removal of $A \to \epsilon$ and $C \to \epsilon$ will be in loop and there are interconnected. Although removing these two epsilons don't affect the other variables as they are not changing anything. That's why those two epsilons are being omitted and we're proceeding to the next step.

(iv) remove unit productions:

for $A' \to A$, $A \to C$, $A \to A$, $C \to A$, $S \to S$

$A' \to 1 \mid 1BS \mid 0S0B \mid 1S \mid 0S0 \mid CA \mid x \mid y \mid \epsilon$
$A \to 1 \mid 1BS \mid 0S0B \mid 1S \mid 0S0 \mid CA \mid x \mid y$
$B \to 1BS \mid 0S0B \mid 1S \mid 0S0$
$C \to x \mid y \mid 1 \mid 1BS \mid 0S0B \mid 1S \mid 0S0 \mid CA$
$S \to 1A1 \mid 0S \mid A1 \mid 11 \mid 1$

(v, v)

$g_0 \to 0$ $\quad P \to g_1 B$

$g_1 \to 1$ $\quad Q \to g_0 S$

$x_1 \to x$ $\quad R \to g_0 B$

$Y_1 \to y$ $\quad T \to g_1 A$

$A' \to 1 \mid PS \mid QR \mid g_1 S \mid Q g_0 \mid CA \mid x \mid y \mid \epsilon$

$A \to 1 \mid PS \mid QR \mid g_1 S \mid Q g_0 \mid CA \mid x \mid y$

$B \to PS \mid QR \mid 1S \mid Q g_0$

$C \to x \mid y \mid 1 \mid PS \mid QR \mid g_1 S \mid Q g_0 \mid CA$

$S \to T g_1 \mid g_0 S \mid A g_1 \mid g_1 g_1 \mid 1$

(Ans).

[P.T.O.]

9. $W \to 2XY \mid 1W \mid 2Y$

$X \to 1X3 \mid 1W3 \mid \epsilon$

$Y \to YY1 \mid 12YW3 \mid X \mid \epsilon$

i) $W' \to W$

$W \to 2XY \mid 1W \mid 2Y$

$X \to 1X3 \mid 1W3 \mid \epsilon$

$Y \to Y11 \mid 12YW3 \mid X \mid \epsilon$

ii) remove null

$X \to \epsilon$:

$W' \to W$

$W \to 2XY \mid 1W \mid 2Y$

$X \to 1X3 \mid 1W3 \mid 13$

$Y \to Y11 \mid 12YW3 \mid X \mid \epsilon$

$Y \to \epsilon$:

$W' \to W$

$W \to 2XY \mid 1W \mid 2Y \mid 2X \mid 2$

$X \to 1X3 \mid 1W3 \mid 13 \mid$

$Y \to Y11 \mid 12YW3 \mid X \mid 11 \mid 12W3$

iii) for $W' \to W$, $Y \to X$

$W' \to 2XY \mid 1W \mid 2Y \mid 2X \mid 2$

$W \to 2XY \mid 1W \mid 2Y \mid 2X \mid 2$

$X \to 1X3 \mid 1W3 \mid 13$

$Y \to Y11 \mid 12YW3 \mid 1X3 \mid 1W3 \mid 13 \mid 11 \mid 12W3$

(iv,v)

$P \to A_2X$ $\quad A_1 \to 1$

$Q \to A_1X$ $\quad A_2 \to 2$

$R \to WA_3$ $\quad A_3 \to 3$

$S \to YA_1$

$T \to A_2Y$

$U \to TR$

$V \to A_1A_2$

$W' \to PY \mid A_1W \mid A_2Y \mid A_2X \mid 2$

$W \to PY \mid A_1W \mid A_2Y \mid A_2X \mid 2$

$X \to QA_3 \mid A_1R \mid A_1A_3$

$Y \to SA_1 \mid A_1U \mid QA_3 \mid A_1R \mid A_1A_3 \mid A_1A_1 \mid VR$

(Ans).