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Automata
Assignment 3

A) $S \to TU \mid V$
$T \to aTb \mid \varepsilon$
$U \to cU \mid \varepsilon$
$V \to aVc \mid W$
$W \to bW \mid \varepsilon$

Adding New Start State

$S_0 \to S$

Removing NULL Production

$\because W \to \varepsilon$

$S_0 \to S$
$S \to TU \mid V$
$T \to aTb \mid \varepsilon$
$U \to cU \mid \varepsilon$
$V \to aVc \mid W \mid \varepsilon$
$W \to bW \mid b$

$\because V \to \varepsilon$

$S_0 \to S$
$S \to TU \mid V \mid \varepsilon$
$T \to aTb \mid \varepsilon$
$U \to cU \mid \varepsilon$
$V \to aVc \mid W \mid ac$
$W \to bW \mid b$

$\because U \to \varepsilon$

$S_0 \to S$
$S \to TU \mid V \mid \varepsilon \mid T$
$T \to aTb \mid \varepsilon$
$U \to cU \mid c$
$V \to aVc \mid W \mid ac$
$W \to bW \mid b$

$\because T \to \varepsilon$

$S_0 \to S$
$S \to TU \mid V \mid \varepsilon \mid T \mid U$
$T \to aTb \mid ab$
$U \to cU \mid c$
$V \to aVc \mid W \mid ac$
$W \to bW \mid b$

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Removing Unit Production

$\because V \rightarrow W$

$S_0 \rightarrow S$
$S \rightarrow TU|V|\varepsilon|T|U|\varepsilon$
$T \rightarrow aTb|ab$
$U \rightarrow cU|c$
$V \rightarrow aVC|bW|b|ac$
$W \rightarrow bW|b$

$\because S_0 \rightarrow S$
$\because S \rightarrow V$
$\because S \rightarrow T$
$\because S \rightarrow U$

$S_0 \rightarrow \varepsilon|TU|aVc|ac|aTb|ab|bW|b|cU|c$
$S \rightarrow TU|aVc|ac|aTb|ab|bW|b|cU|c$
$T \rightarrow aTb|ab$
$U \rightarrow cU|c$
$V \rightarrow aVc|ac|bW|b$
$W \rightarrow bW|b$

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Replacing Terminal/Non Terminal with new variables

$x_1 = C \quad x_2 = aV \quad x_3 = a \quad x_4 = b$
$x_5 = aT$

$S_0 \rightarrow \varepsilon \mid TU \mid x_2x_1 \mid x_3x_1 \mid x_5x_4 \mid x_3x_4 \mid x_4W \mid b \mid x_1U \mid c$
$S \rightarrow TU \mid x_2x_1 \mid x_3x_1 \mid x_5x_4 \mid x_3x_4 \mid x_4W \mid b \mid x_1U \mid c$
$T \rightarrow x_5x_4 \mid x_3x_4$
$U \rightarrow x_1U \mid c$
$V \rightarrow x_2x_1 \mid x_3x_1 \mid x_4W \mid b$
$W \rightarrow x_4W \mid b$

B) $S \rightarrow ASA \mid aB$
$A \rightarrow B \mid S$
$B \rightarrow b \mid \varepsilon$
$X \rightarrow A$

Adding New Start State
$S_0 \rightarrow S$

Removing NULL Production
$\because B \rightarrow \varepsilon$

$S_0 \rightarrow S$
$S \rightarrow ASA \mid aB \mid a$
$A \rightarrow B \mid S \mid \varepsilon$
$B \rightarrow b$
$X \rightarrow A$

$\because A \rightarrow \varepsilon$

$S_0 \rightarrow S$
$S \rightarrow ASA \mid aB \mid a \mid SA \mid AS \mid S$
$A \rightarrow B \mid S$
$B \rightarrow b$
$X \rightarrow A \mid \varepsilon$

$\because X \rightarrow \varepsilon$

$S_0 \rightarrow S$
$S \rightarrow ASA \mid aB \mid a \mid SA \mid AS \mid S$
$A \rightarrow B \mid S$
$B \rightarrow b$
$X \rightarrow A$

Removing Unit Production

$\because S \rightarrow S$
$\because S_0 \rightarrow S$
$\because A \rightarrow B$
$\because A \rightarrow S$
$\because X \rightarrow A$

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$S_0 \rightarrow ASA \mid aB \mid a \mid SA \mid AS$
$S \rightarrow ASA \mid aB \mid a \mid SA \mid AS$
$A \rightarrow b \mid ASA \mid aB \mid a \mid SA \mid AS$
$B \rightarrow b$

Replacing terms with more than 2 terminals or non terminals.

$X \rightarrow AS$
$Y \rightarrow a$

$S_0 \rightarrow XA \mid YB \mid a \mid SA \mid AS$
$S \rightarrow XA \mid YB \mid a \mid SA \mid AS$
$A \rightarrow b \mid A \mid XA \mid YB \mid a \mid SA \mid AS$
$B \rightarrow b$

c) $S \rightarrow a \mid aA \mid aB$
$A \rightarrow aBB \mid \varepsilon$
$B \rightarrow Aa \mid b$

Adding New Start State
$S_0 \rightarrow S$

Removing NULL Production
$\because A \rightarrow \varepsilon$

$S_0 \rightarrow S$
$S \rightarrow a \mid aA \mid aB$
$A \rightarrow aBB$
$B \rightarrow Aa \mid b \mid a$

Removing Duplicate

$S_0 \rightarrow a \mid XA \mid XB$

$A \rightarrow YB$

$B \rightarrow AX \mid b \mid a$

$X \rightarrow a$
$Y \rightarrow aB$