Formal Languages
Ch 4 (p 140-142): 19,27,30,33

19.

G: $S \rightarrow A'F_1 \mid AF_2 \mid a$
$F_1 \rightarrow AF_3$
$F_2 \rightarrow BC$
$F_3 \rightarrow B'B$
$A' \rightarrow a$
$B' \rightarrow b$
$A \rightarrow A'A$
$B \rightarrow B'F_4 \mid b$
$F_4 \rightarrow BF_5$
$F_5 \rightarrow C'C$
$C' \rightarrow c$
$C \rightarrow A'F_6$
$F_6 \rightarrow B'C'$

27.

(a)
　B: (b*abab*) | (aab*abab*(ab | ba)*)

(b)
　$S \rightarrow A \mid B$
　$A \rightarrow aaB \mid aaBZ$
　$Z \rightarrow abZ \mid baZ \mid ab \mid ba$
　$B \rightarrow bB \mid aba \mid abaX$
　$X \rightarrow bX$

30.

$S \rightarrow a \mid aAB'$
$A \rightarrow b \mid aA' \mid aA'AB' \mid aAB' A'AB' \mid aAB'A'$
$B' \rightarrow b$
$A' \rightarrow a$

33.

Original grammar:

$S \rightarrow BA \mid AB \mid .\backslash$
$A \rightarrow BB \mid AA \mid a$
$B \rightarrow AA \mid b$

Removal of left-recursive rules:

$S \rightarrow BA \mid AB \mid .\backslash$
$A \rightarrow BB \mid a \mid BBZ \mid aZ$
$B \rightarrow AA \mid b$

Z → AAZ | AA

Replacement of first variables in incorrect order:

S → BA | AB | .\
A → BB | a | BBZ | aZ
B → BBA | aA | BBZA | aZA
Z → AAZ | AA

Removal of left-recursive rules:

S → BA | AB | .\
A → BB | a | BBZ | aZ
B → aA | aZA | aAZ' | aZAZ'
Z → AAZ | AA
Z' → BBAZ' | BBZAZ' | BBA | BBZA

Replacement of A → Bw productions

S → BA | AB | .\
A → aAB | aZAB | aAZ'B | aZAZ'B | a | aABZ | aZABZ | aAZ'BZ | aZAZ'BZ | aZ
B → aA | aZA | aAZ' | aZAZ'
Z → AAZ | AA
Z' → BBAZ' | BBZAZ' | BBA | BBZA

Replacement of S → Bw productions:

S → aAA | aZAA | aAZ'A | aZAZ'A | AB | .\
A → aAB | aZAB | aAZ'B | aZAZ'B | a | aABZ | aZABZ | aAZ'BZ | aZAZ'BZ | aZ
B → aA | aZA | aAZ' | aZAZ'
Z → AAZ | AA
Z' → BBAZ' | BBZAZ' | BBA | BBZA

Replacement of S → Aw rules:

S → aAA | aZAA | aAZ'A | aZAZ'A | aABB | aZABB | aAZ'BB | aZAZ'BB | aB | aABZB |
aZABZB | aAZ'BZB | aZAZ'BZB | aZB | .\
A → aAB | aZAB | aAZ'B | aZAZ'B | a | aABZ | aZABZ | aAZ'BZ | aZAZ'BZ | aZ
B → aA | aZA | aAZ' | aZAZ'
Z → AAZ | AA
Z' → BBAZ' | BBZAZ' | BBA | BBZA

Replacement of Z → Aw rules:

S → aAA | aZAA | aAZ'A | aZAZ'A | aABB | aZABB | aAZ'BB | aZAZ'BB | aB | aABZB |
aZABZB | aAZ'BZB | aZAZ'BZB | aZB | .\

A → aAB | aZAB | aAZ'B | aZAZ'B | a | aABZ | aZABZ | aAZ'BZ | aZAZ'BZ | aZ
B → aA | aZA | aAZ' | aZAZ'
Z → aABAZ | aZABAZ | aAZ'BAZ | aZAZ'BAZ | aAZ | aABZAZ | aZABZAZ | aAZ'BZAZ |
aZAZ'BZAZ | aZAZ | aABA | aZABA | aAZ'BA | aZAZ'BA | aA | aABZA | aZABZA | aAZ'BZA |
aZAZ'BZA | aZA
Z' → BBAZ' | BBZAZ' | BBA | BBZA

Replacement of Z' → Bw rules (final form):

S → aAA | aZAA | aAZ'A | aZAZ'A | aABB | aZABB | aAZ'BB | aZAZ'BB | aB | aABZB |
aZABZB | aAZ'BZB | aZAZ'BZB | aZB | .\
A → aAB | aZAB | aAZ'B | aZAZ'B | a | aABZ | aZABZ | aAZ'BZ | aZAZ'BZ | aZ
B → aA | aZA | aAZ' | aZAZ'
Z → aABAZ | aZABAZ | aAZ'BAZ | aZAZ'BAZ | aAZ | aABZAZ | aZABZAZ | aAZ'BZAZ |
aZAZ'BZAZ | aZAZ | aABA | aZABA | aAZ'BA | aZAZ'BA | aA | aABZA | aZABZA | aAZ'BZA |
aZAZ'BZA | aZA
Z' → aABAZ' | aZABAZ' | aAZ'BAZ' | aZAZ'BAZ' | aABZAZ' | aZABZAZ' | aAZ'BZAZ' |
aZAZ'BZAZ' | aABA | aZABA | aAZ'BA | aZAZ'BA | aABZA | aZABZA | aAZ'BZA | aZAZ'BZA