1. $S_0 \to S$

$S \to aAa \mid bBb \mid \varepsilon$

$A \to a \mid C$

$B \to b \mid C$

$C \to CDE \mid \varepsilon$

$D \to ab \mid A \mid B$

E is useless since it cannot derive non-terminals

D is useless since it cannot be derived from S

① remove ε-productions:

$S_0 \to S \mid \varepsilon$

$S \to aAa \mid bBb$

$A \to a \mid C \mid \varepsilon$

$B \to b \mid C \mid \varepsilon$

$C \to \varepsilon$

$\Rightarrow$

$S_0 \to S \mid \varepsilon$

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

$A \to a \mid \varepsilon$

$B \to b \mid \varepsilon$

$\Rightarrow$

$S_0 \to S \mid \varepsilon$

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

$A \to a$

$B \to b$

② remove unit production

$S_0 \to aa \mid bb \mid aAa \mid bBb \mid \varepsilon$

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

③ remove useless symbols $\Rightarrow S$

$S_0 \to aa \mid bb \mid aAa \mid bBb \mid \varepsilon$

$A \to a$

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

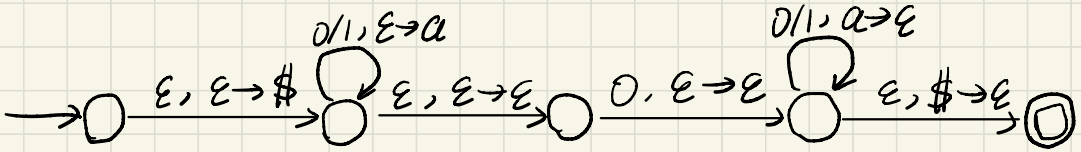
$A \rightarrow a$

$B \rightarrow b$

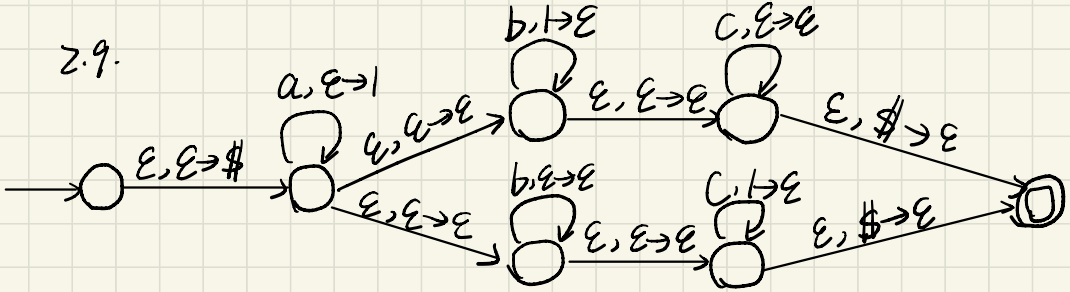
$B \rightarrow b$

2. 2.4.(d):

$(0,1)^k\ 0\ (0,1)^k$



2.9.



3. $|w| = 3k$

ε, ε → #
ε, ε → a
ε, ε → ε
ε, # → ε
ε, ε → a
a, ε → 1
b, ε → 2
a, ε → 1
b, ε → 2
a, ε → 1
b → 2
a, 1 → ε
b, 2 → ε
a, 1 → ε
b, 2 → ε
ε, ε → ε
a, ε → 1
b, ε → 2
a, ε → 1
b, ε → 2
a, ε → 1
b, ε → 2
a, 1 → ε
b, 2 → ε
ε, ε → ε
a, 1 → ε
b, 2 → ε
ε, # → ε

4.