SUNY at Stony Brook **Homework #9**
CSE 303 - Intro. to Theory of Computation **October 25, 2022**

Homework 9 — Due: Tuesday, November 1, 2022

Please submit your work on Brightspace, in PDF format only.

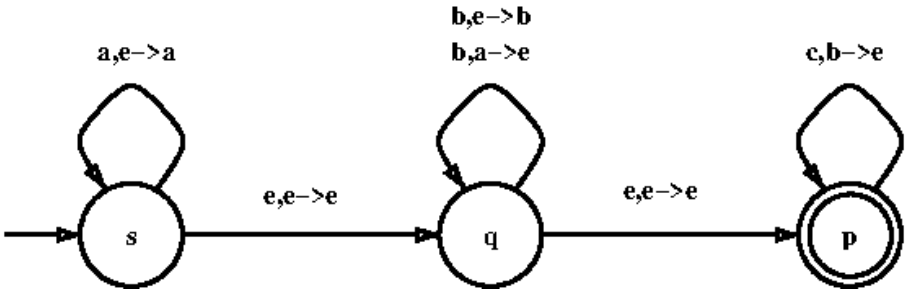
1. Convert the following CFG into an equivalent grammar in Chomsky Normal Form:

$$\begin{aligned} S &\rightarrow aSd \mid A \mid B \\ A &\rightarrow aAc \mid C \\ B &\rightarrow bBd \mid C \\ C &\rightarrow bCc \mid \epsilon \end{aligned}$$

2. Use the procedure in the proof of Sipser Lemma 2.21 to construct a PDA equivalent to the following CFG:

$$\begin{aligned} S &\rightarrow \epsilon \mid aB \mid bA \\ A &\rightarrow aS \mid bAA \\ B &\rightarrow bS \mid aBB \end{aligned}$$

3. Use the procedure of Sipser Lemma 2.27 to construct a CFG equivalent to the following PDA (in the figure, **e** is used in place of ϵ):



Omit variables (and their associated rules) that are useless, where a variable V is *useless* if $\{w \mid V \stackrel{*}{\Rightarrow} w\}$ is empty.

4. Show that if G is a CFG in Chomsky normal form, then for any string w in $L(G)$ of length $n \geq 1$, exactly $2n - 1$ steps are required for any derivation of w.