

# CS311 – Computational Structures – HW7

Thursday, November 8, 2012  
due in class Thursday, November 15, 2012

Answer each question below. Write your answers neatly on paper. Be sure your name is on the paper, and the paper is clearly identified as Homework 7.

1. **PDA to CFG.** Problem 8, Section 12.2, page 778. Show the steps you used in a manner similar to the example given on page 772-773. (Steps 12 points, Draw the PDA 4 points, Final grammar 4 points)
2. **Left recursion removal.** For each of the following grammars, find an equivalent grammar with no left recursion (10 points each).

- $S \rightarrow Sa \mid Sb \mid c$
- $S \rightarrow Sa a S \mid ab$

3.  **$\Lambda$ -removal.** For each of the following grammars, find an equivalent grammar without  $\Lambda$ -productions that generates the same language. (10 points each).

- $S \rightarrow aA \mid aBb$   
 $A \rightarrow aA \mid \Lambda$   
 $B \rightarrow aBb \mid \Lambda$
- $S \rightarrow aAB$   
 $A \rightarrow aAb \mid \Lambda$   
 $B \rightarrow bB \mid \Lambda$

4. **Context Free Pumping Lemma.**

- State the CF pumping lemma. Be sure and get the correct sequence of foralls and exists. (10 points)
- Use the lemma to prove that the languages below are not context free. (15 points each)
  - (a)  $L = \{a^n b c^n d^n \mid n \geq 0\}$
  - (b) The language of all palindromes over  $\{0,1\}$  containing an equal number of 0s and 1s.

When you choose your string, be sure and break your argument in to cases, one for each possible way that your string could be broken into  $xuyvz$ .