

**CURTIN UNIVERSITY OF TECHNOLOGY** (CRICOS number: 00301J)  
**Division of Engineering, Science and Computing**  
**Department of Computing**

**Theoretical Foundations of Computer Science**  
(COMP3002 and COMP5001)

**Work Sheet 4**

**AIM:**

- To explore context-free grammars and push-down automata.
- To formally prove that a language can be generated by a context-free grammar, or that it cannot.

I recommend that you undertake the work in this worksheet as a group activity; however each student is individually responsible for their own learning. If you work in a group, make sure you understand how any answers were arrived at.

The worksheet will not be submitted or marked, and no answers will be given directly. The questions in this sheet will be discussed in the tutorial in week 4 of semester, along with other questions of a similar nature.

**ACTIVITY 1: Discussion Question**

It has been seen that a regular languages can only represent strings that don't involve counting an arbitrarily high number of characters.

- a) Are there similar guidelines for context free grammars?
- b) The language accepting all strings of the form  $ww^R$  where  $w$  is a binary string and  $w^R$  is the reverse of that string forms a CFG. How does this fit into the guidelines from a) above? How about the language  $ww$ ?

**ACTIVITY 2: Push Down Automata and Context-Free Grammars**

Classify each of the following grammars according to its level; Regular, Context Free or neither. Prove your classification.

- a) The language of all accepts binary strings of the form  $0^i1^i0^i$  for some  $i > 0$ .
- b) The language of all accepts binary strings of the form  $0^i1^i0^j$  for some  $i, j > 0$ .
- c) The language of all strings containing the sub-strings '01' and '110'.
- d) The language  $0^i\#1^j$  where  $i < j$ .

**Note:** You can prove that something is regular by creating the appropriate DFA, NFA or Regular Expression, but you can't prove that something is Context Free by creating a PDA or CFG. After all, anything that is Regular can also be represented by a PDA or CFG. Thus you will need to create a PDA or CFG **and** use the pumping lemma to show that it is not regular.

To prove that something is neither Regular nor Context Free, use the pumping lemma for CFGs.

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**End of Work Sheet 4**