

# Homework 1

**Due:** Friday, June 1st, 5 pm, in 324 drop box (SF, 2nd floor, near bridge to LP).

**Lateness reminder:** penalty 30% if handed by Sunday, 5 pm; not accepted later.

**Note:** Print this file and hand in the printout after filling in the answers to the questions. No electronic submission this time. Please use an unsealed envelope, having on top the cover page provided at the end of this file.

## 1 Question 1

The programming language SPL can form boolean expressions over the boolean variables  $p$ ,  $q$ , and  $r$ , using the following boolean operators:

$\rightarrow$ , or, neither, and, not-both

The operators above are given in increasing order of precedence, with operators on the same level having the same precedence.

Operators	Associativity
$\rightarrow$	right
or, neither	left
and, not-both	left

Examples of accepted sentences:  $p \rightarrow q$  or  $r$ ,  $p$  and  $(r$  neither  $q)$ ,  $q$  not-both  $p$  or  $q$ .

**a.** Develop an expression grammar (in BNF) for this subset of SPL operators, considering the right precedence and associativity of operators.

**b.** Draw a parse tree for the following expressions using the grammar you developed at **a**:

$p$  or  $q$  and  $r$

$p \rightarrow q$  and  $(r$  neither  $p)$

**Solution:**

**a.**

**b.** Parse tree for:  $p$  or  $q$  and  $r$

Parse tree for:  $p \rightarrow q$  and ( $r$  neither  $p$ )

## 2 Question 2

For each of the following CFGs say if the grammar is ambiguous or not. If your answer is yes, show an example of a string which has two different parse trees, and provide an unambiguous equivalent grammar. If your answer is no, briefly explain why you think this.

1.  $\langle X \rangle ::= 0 \langle X \rangle \mid \langle X \rangle 0 \mid 1$

Is the grammar ambiguous (circle one)?      Yes      No

If yes, example of string with two parse trees:

Unambiguous equivalent grammar:

If no, explain why:

2.  $\langle X \rangle ::= 0 \langle X \rangle \mid 1 \langle X \rangle \mid 11$

Is the grammar ambiguous (circle one)?      Yes      No

If yes, example of string with two parse trees:

Unambiguous equivalent grammar:

If no, explain why:

3.  $\langle X \rangle ::= \langle X \rangle 0 \langle X \rangle \mid \langle X \rangle 1 \langle X \rangle \mid \epsilon$

Is the grammar ambiguous (circle one)?      Yes      No

If yes, example of string with two parse trees:

Unambiguous equivalent grammar:

If no, explain why:

### 3 Question 3

Consider the language described by the following regular expression over the alphabet  $\{s,t,a,i,r,p\}$ :

$$\begin{array}{c} (t|st^*)^+ (a|i) (r|p)^* \\ \hline \begin{array}{ccc} 1 & 2 & 3 \end{array} \end{array}$$

(Note that the '\*' and '+' symbols in this expression have the usual meaning for regular expressions.)

For each of the following strings, say whether or not it is in the language. Label the parts of the string that correspond to the parts indicated above by 1, 2 and 3.

1. ta                      Circle one:      Yes      No

2. stp                      Circle one:      Yes      No

3. tsar                      Circle one:      Yes      No

4. stair                      Circle one:      Yes      No

5. tarp                      Circle one:      Yes      No

6. sir                      Circle one:      Yes      No

## 4 Question 4

For each of the following languages write a regular expression (or say it cannot be done) and write a CFG using BNF notation (or say it cannot be done).

1. All strings of *as* and *bs* containing an even number of *as* and an even number of *bs*. Examples: *aabb*, *abab*, *aabbaabbaab*.

RE:

CFG:

2. All strings of *as*, *bs* and *cs*, containing a number of *as* ( $\geq 0$ ), followed by the same number *bs* or *cs*. Examples: *aaabcb*, *aabb*, *aaaabccb*, *aaaaabcbcc*.

RE:

CFG:

3. All strings of *as*, *bs* and *cs*, containing a number *n* of *a* ( $0 \leq n \leq 5$ ), followed by  $5 - n$  *bs*, followed by *n cs*. Examples: *bbbbbb*, *abbbbc*, *aabbbcc*, *aaabbcccc*, *aaaabccccc*, *aaaaaccccc*.

RE:

CFG:

## Cover Page for Homework 1

Family name: \_\_\_\_\_ Student #: \_\_\_\_\_

First name: \_\_\_\_\_ CDF id: \_\_\_\_\_

TA name:        HaiTao Zhang        Ramona Truta        Cosmin Truta        Tristan Miller

I declare that this assignment is my own work, and it is in accordance with the University of Toronto Code of Behaviour on Academic Matters and the Code of Student Conduct.

I discussed this assignment with the following people:

Name: \_\_\_\_\_ Name: \_\_\_\_\_

Name: \_\_\_\_\_ Name: \_\_\_\_\_

Signature \_\_\_\_\_