

Homework 3  
CS 4481

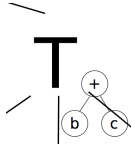
1. (10 points) Consider the following grammar.

- R1. Goal  $\rightarrow$  List
- R2. List  $\rightarrow$  List Pair
- R3.       | Pair
- R4. Pair  $\rightarrow$  ( Pair )
- R5.       | ( )

Given the input  $()()$  into a bottom-up parser and the first few steps of the parse given below, complete the table. Let “s” be some state. Reduce whenever you can, except only reduce on R1 when the next token is eof and reduce on R3 if the next token is not ).

stack	word	action
\$ s	(	shift
\$ s ( s	)	shift
\$ s ( s ) s	(	reduce R5
\$ s Pair s	(	reduce R3

2. (10 points) Based on the following evaluation rules, draw an annotated parse tree that shows how the syntax tree for  $a-(b+c)$  is constructed. `mknode()` is similar to what is described on page 205 of the textbook. A good way to do this is to first draw the parse tree, then annotate the leaves and propagate the annotations up the tree. One of your parse tree nodes will look like this (the node is a grammar symbol and the annotation is a graph):



Here is the grammar:

Production	Evaluation Rules
$E_0 \rightarrow E_1 + T$	$E_0.nptr \leftarrow \text{mknode}(+, E_1.nptr, T.nptr)$
$E_0 \rightarrow E_1 - T$	$E_0.nptr \leftarrow \text{mknode}(-, E_1.nptr, T.nptr)$
$E_0 \rightarrow T$	$E_0.nptr \leftarrow T.nptr$
$T \rightarrow (E)$	$T.nptr \leftarrow E.nptr$
$T \rightarrow \text{id}$	$T.nptr \leftarrow \text{mknode}(\text{id})$

3. Consider the following code fragment:

```
if (c[i] ≠ 0)
  then a[i] ← b[i] ÷ c[i];
  else a[i] ← b[i];
```

(a) (4 points) Draw an abstract syntax tree representation of this code (see section 5.2, and Fig 5.2 (left side) in particular—think: how many children does an “if” node have?).

- (b) (3 points) Draw a control-flow graph representation of the code (see section 5.2.2, and Fig at bottom of pg. 231 in particular).
  - (c) (3 points) What are the advantages of each representation?
4. You are writing a compiler for a simple lexically-scoped language. Consider the example program shown in Figure 5.16 on page 268 of the textbook.
- (a) (5 points) Draw the symbol table and its contents at line 11 (don't forget procedure names and params).
  - (b) (5 points) What actions are required for symbol table management when the parser enters a new procedure and when it exits a procedure?