

# FINAL EXAM

*Please read all instructions, including these, carefully*

- There are 9 questions on the exam, with multiple parts. You have 3 hours to work on the exam.
- The exam is open book, open notes.
- Please write your answers in the space provided on the exam and clearly mark your solutions.
- You may use the backs of the exam pages as scratch paper, or use additional pages (available at the front of the room).
- Each problem has a straightforward solution. Solutions will be graded on correctness and clarity. Partial solutions will be given partial credit.

NAME : \_\_\_\_\_

Problem	Max points	Points
1	10	
2	15	
3	10	
4	10	
5	10	
6	10	
7	10	
8	10	
9	15	
TOTAL	100	

1. (a) Using the grammar below, draw a derivation tree for the following string:

**(( id . id ) id ( id ) ( ( ) ) )**

$$\begin{array}{l} S \rightarrow E \\ E \rightarrow \text{id} \\ \quad | ( E . E ) \\ \quad | ( L ) \\ \quad | ( ) \\ L \rightarrow L E \\ \quad | E \end{array}$$

- (b) Give a rightmost canonical derivation for the string given in part (a).

2. Consider the following grammar:

- 1  $S \rightarrow ABA$
- 2  $A \rightarrow Bc$
- 3       |  $dA$
- 4       |  $\epsilon$
- 5  $B \rightarrow eA$

(a) Fill in the table below with the FIRST and FOLLOW sets for the non-terminals in this grammar:

	<i>First</i>	<i>Follow</i>
S		
A		
B		

(b) Fill in the LL(1) parse table for this grammar.

	$x$	$y$	$\$$
$S$			
$A$			
$B$			

3. Consider the following grammar for boolean expressions (words in capitals are terminals).

$$\begin{aligned} E &\rightarrow E \text{ OR } E \\ E &\rightarrow E \text{ AND } E \\ E &\rightarrow \text{NOT } E \\ E &\rightarrow ( E ) \\ E &\rightarrow \text{TRUE} \\ E &\rightarrow \text{FALSE} \\ E &\rightarrow \text{ID} \end{aligned}$$

- (a) Show that this grammar is ambiguous.

- (b) Rewrite the grammar to remove the ambiguity and enforce the intended precedence order by introducing new non-terminals. Make sure that your revised grammar accepts the same language as the original.

4. Consider the following context free grammar:

$$\begin{array}{l} S \rightarrow Aa \\ \quad | bAc \\ \quad | dc \\ \quad | bda \\ A \rightarrow d \end{array}$$

(a) Is the grammar SLR(1)? Why or why not? You don't need to construct the parse table to answer.

(b) Is the grammar LR(1)? Why or why not?

(c) Consider the following context free grammar for the same language:

$$\begin{array}{l} S \rightarrow Aa \\ \quad | bAc \\ \quad | Bc \\ \quad | bBa \\ A \rightarrow d \\ B \rightarrow d \end{array}$$

Is this grammar LR(1)? Why or why not?

5. Let  $G$  be the following grammar:

- 1  $S \rightarrow [ SX ]$
- 2  $\quad \quad | a$
- 3  $X \rightarrow \varepsilon$
- 4  $\quad \quad | + SY$
- 5  $\quad \quad | Yb$
- 6  $Y \rightarrow \varepsilon$
- 7  $\quad \quad | - SXc$

(a) Show the parse tree for the following string :

**$a + a - ac$**

(b) Complete the table below tracing an LR(1) parse of the same string. The *Stack* column shows the stack (with the top at right), the *Input* column shows the not-yet-processed input, and the *Action* column shows whether the parser performs a shift action, a reduce action, or accepts the input. In the case of a reduce action, indicate (by number) which production is used. (NOTE: you do not need to construct the parse table; just use your knowledge of how the parser works and the parse tree above).

Stack (with top at right)	Input	Action

6. You may give any context-free grammar in answer to the questions in this part; we are not looking for LL(1) grammars, or unambiguous grammars, or any other subclass of all context free grammars.

(a) Consider the following FIRST and FOLLOW sets:

$$\begin{aligned}\text{FIRST}(S) &= \{b, \epsilon\} \\ \text{FIRST}(T) &= \{b, \epsilon\} \\ \text{FOLLOW}(S) &= \{a, \$\} \\ \text{FOLLOW}(T) &= \{a, b, \$\}\end{aligned}$$

Give the simplest grammar (fewest productions and shortest right-hand sides) that produces these sets.  $S$  is the start symbol.

(b) Give a grammar with a single non-terminal  $S$  such that  $\text{FIRST}(S) = \emptyset$ .

(c) Give a grammar with a single non-terminal  $S$  such that  $\text{FIRST}(S) = (\text{FOLLOW}(S) - \{\$\}) = \emptyset$ .

(d) Give a simple example of a grammar with a shift-reduce conflict.

7. For each grammar explain why, or why not, the grammar is LL(1):

(a)  $S \rightarrow 0 \mid 12 \mid 345$

(b)  $S \rightarrow 0 \mid T1$   
 $T \rightarrow 1 \mid S0$

(c)  $S \rightarrow 0 \mid 11 \mid 01$

8. Let synthesized attribute  $F.val$  give the value of the binary fraction generated by  $F$  in the grammar that follows:

$$\begin{aligned} F &\rightarrow .L \\ L &\rightarrow LB \mid B \\ B &\rightarrow 0 \mid 1 \end{aligned}$$

For instance, on input **.101**,  $F.val = .625$ .

- (a) Using only synthesized attributes, give a translation scheme for the above grammar.

- (b) Show the translation of the input string **.101** by decorating its parse tree. Make sure your tree is drawn clearly.

9. Consider the following parsing automaton. All that is shown are the states, transitions, and the left-hand side of each item that has the “•” all the way to right. Complete the partial items and fill

