

Computer Science Comprehensive Exam—Spring 2000
Compiler Construction

Instructions: Please answer all the questions directly on the exam itself. Answer **all** the questions. Explain answers as fully as possible, give examples if appropriate, define terms.

1. Describe how a compiler translates **new**, dynamic memory allocation, with reference to the runtime organization of the program.

2. Describe how to implement non-local variable access in typical block-structured, statically-scoped programming languages.

3. Consider the following augmented grammar:

$$\begin{aligned}
 E' &\rightarrow E\$ \\
 E &\rightarrow -E \\
 E &\rightarrow (E) \\
 E &\rightarrow VT \\
 T &\rightarrow -E \\
 T &\rightarrow \epsilon \\
 V &\rightarrow \mathbf{id}L \\
 L &\rightarrow (E) \\
 L &\rightarrow \epsilon
 \end{aligned}$$

(a) Compute the *FIRST* and *FOLLOW* for all nonterminals.

	<i>FIRST</i>	<i>FOLLOW</i>
<i>E</i>		
<i>T</i>		
<i>V</i>		
<i>L</i>		

(b) Compute the *FIRST* of the right-hand side of all productions.

	α	<i>FIRST</i> (α)
1	$E \rightarrow -E$	
2	$E \rightarrow (E)$	
3	$E \rightarrow VT$	
4	$T \rightarrow -E$	
5	$T \rightarrow \epsilon$	
6	$V \rightarrow \mathbf{id}L$	
7	$L \rightarrow (E)$	
8	$L \rightarrow \epsilon$	

(c) Complete the first row (**and only the first row**) of the LL(1) parse table below.

	-	()	id	\$
E					
T	$T \rightarrow - E$			$T \rightarrow \epsilon$	$T \rightarrow \epsilon$
V				$V \rightarrow \mathbf{id} L$	
L	$L \rightarrow \epsilon$	$L \rightarrow (E)$	$L \rightarrow \epsilon$		$L \rightarrow \epsilon$

4. Consider the following grammar.

- 1 $N \rightarrow ND$
- 2 $N \rightarrow D$
- 3 $D \rightarrow a$
- 4 $D \rightarrow b$

Using the given LR parsing table, show the parsing steps of the string **aab** by filling in the next two steps of the diagram.

state	action			goto	
	a	b	\$	N	D
0	s3	s4		1	2
1	s3	s4	acc		5
2	r2	r2	r2		
3	r3	r3	r3		
4	r4	r4	r4		
5	r1	r1	r1		

stack	input	action
(1) 0	aab \$	shift 3
(2) 0 a 3	ab \$	reduce by $D \rightarrow a$
(3) 0 D 2	ab \$	
(4)		
(5)		

5. Consider the following augmented grammar.

$$\begin{aligned} S' &\rightarrow S\$ \\ S &\rightarrow CC \\ C &\rightarrow cC \\ C &\rightarrow \mathbf{d} \end{aligned}$$

Begin the LR(1) item set construction for the grammar. What is the initial state? What is the next state, if you choose the transition C ?