Computer Science Comprehensive Exam—Fall 2009
Compiler Construction (with some answers)

Instructions: Do *not* put your name on the exam, please answer all the questions directly on the exam itself. You may need scratch paper. Answer **all** the questions. Explain answers as fully as possible, give examples or define terms, if appropriate.

1. In general terms, what are the major steps of the typical compiler for an imperative language?

   Answer:

2. What is the formal definition of the FIRST(N) for some nonterminal N of a grammar?

   Answer:

3. Consider the algorithm to compute CLOSE[I] for the set I of LR(1) items for some grammar. Suppose the grammar contains the production $X \rightarrow \gamma$ where X is some non-terminal and γ is some string of terminals and non-terminals. Answer the following questions assuming A is some non-terminal, α and β are strings of terminals and non-terminals, and y and z are terminal symbols.

   (a) If $A \rightarrow \alpha \bullet X$, z is in I, which item or items (if any) would be added to CLOSE[I]?
   Answer: Add $X \rightarrow \bullet\gamma$, z to CLOSE[I].

   (b) If $A \rightarrow \alpha \bullet Xy$, z is in I, which item or items (if any) would be added to CLOSE[I]?
   Answer: Add $X \rightarrow \bullet\gamma$, y to CLOSE[I].

   (c) If $A \rightarrow \alpha \bullet X\beta$, z is in I, which item or items (if any) would be added to CLOSE[I]?
   Answer: For any $w \in$ FIRST[βz], add $X \rightarrow \bullet\gamma$, w to CLOSE[I].

4. (Appel, exercise 3.5.) Consider the following grammar.

1	S	$\rightarrow$	
2	S	$\rightarrow$	$X\,S$
3	B	$\rightarrow$	**/ begin { word }**
4	E	$\rightarrow$	**/ end { word }**
5	X	$\rightarrow$	$B\,S\,E$
6	X	$\rightarrow$	**{** S **}**
7	X	$\rightarrow$	**word**
8	X	$\rightarrow$	**begin**
9	X	$\rightarrow$	**end**
10	X	$\rightarrow$	**/ word**

(a) Compute nullable, FIRST, and FOLLOW for all nonterminals of the grammar.

	nullable	FIRST	FOLLOW
S	*yes*	/, **{**, **word**, **begin**, **end**	
B	*no*	/	
E	*no*	a, c	$b, \$$
X	*no*	c	$b, \$$

(b) Fill in the LL(1) parse table below for the indicated terminals.

	word	/	**{**	**}**	**begin**	**end**
S			2			
B		6				
E		4				
X		**3 & 10**	6		8	9

Answer:

(c) Is the grammar LL(1)?

Answer: No.

5. (Appel, exercise 3.11.) Construct the LR(0) parsing table for the following grammar. And, is the grammar SLR? Explain.

$$
\begin{array}{lrcl}
0 & S' & \rightarrow & B\,\$ \\
1 & B & \rightarrow & \mathbf{id}\,P \\
2 & B & \rightarrow & \mathbf{id}\,(\,E\,] \\
3 & P & \rightarrow & \\
4 & P & \rightarrow & (\,E\,) \\
5 & E & \rightarrow & B \\
6 & E & \rightarrow & B\,,\,E
\end{array}
$$

6. (Appel, exercise 3.14.) Construct the LR(1) parsing table for the following grammar.

$$
\begin{array}{lrcl}
0 & S' & \to & S\,\$ \\
1 & S & \to & (\,X \\
2 & S & \to & E\,] \\
3 & S & \to & F\,) \\
4 & X & \to & E\,) \\
5 & X & \to & F\,] \\
6 & E & \to & A \\
7 & F & \to & A \\
8 & A & \to &
\end{array}
$$