Computer Science Comprehensive Exam—Spring 2013
Compiler Construction

Instructions: Do *not* put your name on the exam, please answer all the questions directly on the exam itself. You may write on the back of the pages. You may need scratch paper to work out the answers before writing them on the exam. Answer **all** the questions. You have 90 minutes. Explain answers as fully as possible, give examples or define terms, if appropriate.

1. What are assemblers, linkers, and loaders?

2. Give a regular expression for all sequences of 0's and 1's that

   (a) contain exactly three 1's.

   (b) contain no consecutive 0s.

   (c) contain an even number of 0s.

3. Give a (simple) grammar for which the following two LR(1) items appear in the same state of the LR(1) parsing automaton. Or, explain why it cannot happen. A, B, P, Q, and R are non-terminals; and x and y are terminals.

$$A \to P \bullet Q, x \qquad B \to R \bullet Q, y$$

4. Consider the following grammar:

$$
\begin{aligned}
S &\rightarrow u\,B\,D\,z \\
B &\rightarrow B\,v \\
B &\rightarrow w \\
D &\rightarrow E\,F \\
E &\rightarrow y \\
E &\rightarrow \epsilon \\
F &\rightarrow x \\
F &\rightarrow \epsilon
\end{aligned}
$$

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

	nullable	FIRST	FOLLOW
S			
B			
D			
E			
F			

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

	α	FIRST(α)
1	$S \rightarrow u\,B\,D\,z$	
2	$B \rightarrow B\,v$	
3	$B \rightarrow w$	
4	$D \rightarrow E\,F$	
5	$E \rightarrow y$	
6	$E \rightarrow \epsilon$	
7	$F \rightarrow x$	
8	$F \rightarrow \epsilon$	

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

	w	u	v	x	y	z
S						
B						
D						
E						
F						

(d) Is the grammar LL(1)? Explain.

(e) Is the grammar LL(2)? Explain.

5. 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 σ are strings of terminals and non-terminals, and y and l are terminal symbols.

   (a) If $A \rightarrow \alpha\bullet$, l is in I, which item or items (if any) would be added to CLOSE[I]?

   (b) If $A \rightarrow \alpha \bullet X$, l is in I, which item or items (if any) would be added to CLOSE[I]?

   (c) If $A \rightarrow \alpha \bullet Xy$, l is in I, which item or items (if any) would be added to CLOSE[I]?

   (d) If $A \rightarrow \alpha \bullet X\sigma$, l is in I, which item or items (if any) would be added to CLOSE[I]?

6. For the following augmented grammar:

$$
\begin{array}{lrcl}
0 & S' & \rightarrow & S\,\$ \\
1 & S & \rightarrow & a\,A \\
2 & S & \rightarrow & b\,B \\
3 & A & \rightarrow & C\,a \\
4 & A & \rightarrow & D\,b \\
5 & B & \rightarrow & C\,b \\
6 & B & \rightarrow & D\,a \\
7 & C & \rightarrow & E \\
8 & D & \rightarrow & E \\
9 & E & \rightarrow &
\end{array}
$$

(a) Give a diagram of the LR(1) states and transitions.

(b) Give the LR(1) parsing tables.

(c) Is the grammar LR(1)? Explain.

(d) Is the grammar LALR(1)? Explain.