Name (Last, First): _____, _____

Midterm Examination
May 8th 1997

Score: _____/100

Directions

- This exam consists of 3 questions on 6 pages; be sure that you have the entire exam before starting.
- Make sure that you write your name on every page of the exam.
- Answer each question in the space following the question. If you find it necessary to continue an answer elsewhere, indicate clearly the location of its continuation and label its continuation with the question number.
- The point value of each question is indicated at its beginning. The entire exam has 100 points.
- Be concise and indicate clearly what your answer is. Presentation and simplicity of your answers may affect your grade.
- You have 80 minutes.

Problem 1 (35 Points)

Problems 1.a and 1.b require you to construct a predictive parser for the following grammer:

$$
\begin{aligned}
Expr &\rightarrow -Expr \mid (Expr) \mid Var\ ExprTail \\
ExprTail &\rightarrow -Expr \mid \epsilon \\
Var &\rightarrow \textbf{id}\ VarTail \\
VarTail &\rightarrow (Expr) \mid \epsilon
\end{aligned}
$$

1.a) (8 Points) Find $First$ and $Follow$ sets for the nonterminals of the grammar:

First(Expr) = Follow(Expr) =

First(Var) = Follow(Var) =

First(ExprTail) = Follow(ExprTail) =

First(VarTail) = Follow(VarTail) =

1.b (11 Points) Show the predictive parser table for the grammar

	id	–	(	)	$
Expr					
ExprTail					
Var					
VarTail					

1.c (3+5 Points) Is the following grammar LL(1)? Give reasons for your answer.

$$
\begin{array}{lcl}
S & \rightarrow & ABBA \\
A & \rightarrow & a \mid \epsilon \\
B & \rightarrow & b \mid \epsilon
\end{array}
$$

1.d (3+5 Points) Is the following grammar LL(1)? Give reasons for your answer.

$$
\begin{array}{lcl}
S & \rightarrow & a\,S\,e \mid B \\
B & \rightarrow & b\,B\,e \mid C \\
C & \rightarrow & c\,C\,e \mid d
\end{array}
$$

Problem 2 (35 Points)

This problem deals with LR(1), LALR(1), and LR(1) parsers. The context free grammar of interest in problems 2.a and 2.b is:

1. $SL \rightarrow SL; S$
2. $SL \rightarrow \epsilon$
3. $S \rightarrow$ **stmt**

2.a (13 Points) Construct LR(0) items for the grammar.

2.b (12 Points) Construct the SLR(1) parser table for the grammar.

2.c (3+7 Points) Is the following grammar an LR(1) grammar? Describe the reasons for your answer.

1. $S \rightarrow$ **id** $:= A;$
2. $A \rightarrow$ **id** $:= A \mid E$
3. $E \rightarrow E + P \mid P$
4. $P \rightarrow$ **id** $\mid (A)$

Problem 3 (30 Points)

This problem deals with attributed grammars and semantic analysis.

3.a (15 Points) Consider the following grammar for specifying binary trees (in linearized form):

$$BinTree \rightarrow (\textbf{num}\ BinTree_1\ BinTree_2) \mid \epsilon$$

Extend the above grammar by defining a translation scheme such that a depth-first left-to-right traversal of a parse tree (denoting a binary tree) annotated with semantic actions will entail checking if the binary tree is ordered. A binary tree is ordered if the values of the numbers of the first subtree ($BinTree_1$) are less than the value of the current number and the values of the numbers of the send subtree ($BinTree_2$) are greater than the value of the current number. For instance, `(2 (1 nil nil) (3 nil nil))` is ordered but `(1 (2 nil nil) (3 nil nil))` is not. Note that you can use any language constructs (such assignments, if-then-else, expressions, boolean expressions etc.) for writing the semantic rules.

3.b (15 Points) The following grammar denotes a language $L = \{a^n c^m d^m b^n, n \geq 0, m \geq 0\}$.

$$\begin{aligned} D &\rightarrow a\ D_1\ b \mid C \\ C &\rightarrow c\ C_1\ d \mid \epsilon \end{aligned}$$

Extend the above grammar by defining a translation scheme such that an execution of the translation scheme will output a string where each occurrence of c is replaced by an occurrence of a and each occurrence of d by an occurrence of b. For instance, a translation of *aaccddbb* will result in *aaaabbbb*, whereas a translation of *aacccdddbb* will result in *aaaacbbdbb*. Note that if $m > n$, only $m - n$ c's or d's are replaced. Also, note the order of c's and d's replaced. However, if $m \leq n$, all c's and d's are replaced by a's and b's.