

Problem 1 (20 points)

Consider the grammar

$$\begin{aligned} S &\rightarrow (L) \mid a \\ L &\rightarrow L , S \mid S \end{aligned}$$

- (a) What are the terminals, nonterminals and start symbol?
- (b) Find parse trees for the following sentences:
 - i) (a, a)
 - ii) (a, (a, a))
- (c) Construct the leftmost derivation for each of the sentences in (b)
- (d) Construct the rightmost derivation for each of the sentences in (b)

Problem 2 (20 points)

Consider the grammar

$$S \rightarrow aSbS \mid bSaS \mid \epsilon$$

- (a) Show the grammar is ambiguous by constructing two different leftmost derivations for the sentence *abab*.
- (b) Construct the corresponding rightmost derivations for *abab*.
- (c) Construct the corresponding parse trees from parts (a) and (b) for *abab*.
- (d) What can you conclude from the parse trees in part (d)?

Problem 3 (20 points)

A grammar symbol X is *defunct* if there is no derivation of the form $S \Rightarrow^* wXy \Rightarrow^* wxy$, where $X \in V$ and $w, x, y \in \Sigma^*$. That is, X can never appear in the derivation of some sentence.

- (a) Write an algorithm to eliminate all productions containing defunct symbols from the grammar.
- (b) Apply your algorithm to the grammar below. Describe the steps your algorithm takes.

$$\begin{aligned} S &\rightarrow 0 \mid A \\ A &\rightarrow AB \\ B &\rightarrow 1 \end{aligned}$$

Problem 4 (40 points)

Check if the grammar described below is a member of LL(1) languages, if not convert it. Use left recursion elimination, left factoring and more if necessary; show your work by noting the first, follows and the augmented first sets (Hint: You may need to do more than algorithmic changes to the grammar.) Provide an LL(1) parsing table for the grammar, if applicable. (Hint: You may also check the LL(1) condition by using the table.)

LIST	→	LIST :: ELEM EMPTYLIST
EMPTYLIST	→	nil
ELEM	→	lparen DATA rparen lparen rparen
DATA	→	0 NONZERONUMBER
NONZERODIGIT	→	1 2 3 4 5 6 7 8 9
NONZERONUMBER	→	NONZERONUMBER NONZERONUMBER NONZERONUMBER NONZERODIGIT NONZERONUMBER 0 NONZERODIGIT