Submissions are due by the beginning of class on the specified due date. Handwritten or typed solutions are acceptable. If you do write your solutions by hand, be sure to write clearly. If the grader cannot read your answer, they cannot give you the points. Late submissions will be accepted for 10% off every 24 hours they are late (up to 48 hours).

1. (50 points) Write semantic actions for the following grammar to convert an infix expression to a postfix expression that is stored in $E.post$ at the root node of the parse tree (25 points), assuming $+$ and $-$ are left associative. Literal terminal tokens have been designated with double-quotes for clarity. The token $num$ is also a terminal token.

$$
E \rightarrow E \ "+" \ E \\
E \rightarrow E \ "-" \ E \\
E \rightarrow "(" \ E \ ")" \\
E \rightarrow \text{num}
$$

Draw a decorated parse tree for the input “10 + ( 20 + 5 ) - 30” (the postfix expression should be “10 20 5 + + 30 -”). (25 points)

2. (50 points) Augment the following grammar of the language of nested parentheses with semantic rules to print the number of matching parentheses in an expression (25 points):

$$
P \rightarrow E \\
E \rightarrow "(" \ E \ ")" \\
E \rightarrow E \ E \\
E \rightarrow \epsilon
$$

Draw a decorated parse tree for the input “(()()()”: the grammar should output 4. (25 points)