1. Rewrite the BNF grammar above to give + precedence over * and force + to be right associative.

2. Using the grammar provided above, show a parse tree and a leftmost derivation for each of the following statements:
   a. \( A = ( A + B ) * C \)
   b. \( A = B * ( C * ( A + B ) ) \)

3. Prove that the following grammar is ambiguous:

   \[ \langle S \rangle \rightarrow \langle A \rangle \]
   \[ \langle A \rangle \rightarrow \langle A \rangle + \langle A \rangle + \langle A \rangle | \langle id \rangle \]
   \[ \langle id \rangle \rightarrow a | b | c \]

4. Consider the following grammar:

   \[ \langle S \rangle \rightarrow \langle A \rangle \ a \ \langle B \rangle \ b \]
   \[ \langle A \rangle \rightarrow \langle A \rangle \ b | b \]
   \[ \langle B \rangle \rightarrow a \ \langle B \rangle | a \]

   Which of the following sentences are in the language generated by this grammar?
   a. baab
   b. bbbbab
   c. bbaaaaaa
   d. bbaab

5. Write a grammar for the language consisting of strings that have \( n \) copies of the letter a followed by the same number of copies of the letter b, where \( n > 0 \).
6. Write an attribute grammar whose BNF basis is the grammar below but whose language rules are as follows: Data types cannot be mixed in expressions, but assignment statements need not have the same types on both sides of the assignment operator.

\[
\begin{align*}
\text{<assign>} & \rightarrow \text{<var> } = \text{<expr>} \\
\text{<expr>} & \rightarrow \text{<var>}[2] + \text{<var>}[3] \mid \text{<var>} \\
\text{<var>} & \rightarrow \text{A \mid B \mid C}
\end{align*}
\]

7. Consider the syntax rule and the semantic function below:

\[
\begin{align*}
\text{<bin_num>} & \rightarrow \text{‘0’ \mid ‘1’ \mid <bin_num> ‘0’ \mid <bin_num> ‘1’} \\
M_{\text{bin}}(\text{‘0’}) & = 0 \\
M_{\text{bin}}(\text{‘1’}) & = 1 \\
M_{\text{bin}}(\text{<bin_num> ‘0’}) & = 2 \times M_{\text{bin}}(\text{<bin_num>} ) \\
M_{\text{bin}}(\text{<bin_num> ‘1’}) & = 2 \times M_{\text{bin}}(\text{<bin_num>} ) + 1
\end{align*}
\]

What is the value of the sequence of characters ‘1001’? (Show your work)

8. Axiomatic Semantics

Compute the weakest precondition for each of the following:

\[
\begin{align*}
a & = 2 \times (b - 1) - 1 \quad \{a > 0\} \\
b & = 2 \times b + 1; \\
b & = a - 3; \\
\{b < 0\}
\end{align*}
\]

Prove that the following program segment is correct:

\[
\begin{align*}
c & > 4 \\
c & = b - 3; \\
a & = c + 2; \\
\{a \geq 2\}
\end{align*}
\]