1. Consider the following grammar for simple Pascal-style declarations:

<table>
<thead>
<tr>
<th>Grammar Rule</th>
<th>Semantic Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>decl → type var-list;</td>
<td>var-list.type = type.type</td>
</tr>
<tr>
<td>var-list → var-list', id</td>
<td>var-list.type → var-list'.type</td>
</tr>
<tr>
<td></td>
<td>enter (id.name, var-list.type)</td>
</tr>
<tr>
<td>var-list → id</td>
<td>enter (id.name, var-list.type)</td>
</tr>
<tr>
<td>type → integer</td>
<td>type.type = integer</td>
</tr>
<tr>
<td>type → real</td>
<td>type.type = real</td>
</tr>
</tbody>
</table>

a. Draw the annotated parse tree for the string \texttt{a, b: integer}, where “enter” is a semantic action that enters an identifier into the symbol table together with its type. The annotated parse tree must be augmented the semantic action “enter” (9 marks)

b. Is this grammar l-attributed grammar? Explain your answer (3 marks)

c. Identify the type of each attribute as inherited or synthesized and justify your answer (3 mark)
2. Consider the following grammar:

\[
\begin{align*}
exp & \rightarrow n \; \text{exp}' \\
\text{exp}' & \rightarrow / \; n \; \text{exp}' \mid \varepsilon \\
n & \rightarrow \text{num} \mid \text{num.num}
\end{align*}
\]

Write an attribute grammar that determines the type of the expression (exp) according to the following rule if the two operands of the division operator (/) are of integer type, the type of the result is integer else the type of the result is real.

(10 marks)
3. Given the following CFG grammar.

\[
\begin{align*}
\text{based-num} & \rightarrow \text{num basechar} \\
\text{basechar} & \rightarrow o \mid d \\
\text{num} & \rightarrow \text{num digit} \mid \text{digit} \\
\text{digit} & \rightarrow 0 \mid 1 \mid 2 \mid 3 \ldots \ldots \mid 9
\end{align*}
\]

a. Write an attribute grammar to compute the value of a decimal or an octal number based on the one-character suffix o (for octal) and d (for decimal). An error must be signaled if the base is octal and the digit value is greater than 7. (\textbf{Hint:} Use two attributes for the number and the digit, one for the value and the second for the base.)

(b) (10 marks)

b. Is this grammar an L-attribute grammar and Why? (5 marks)
Given the following grammar:

\[
E \rightarrow ET+ | T \\
T \rightarrow id
\]

a) Construct the DFA of LR (1) items for this grammar (10 marks)

b) Construct the LR (1) parsing table (5 marks)
c) Show the parsing stack and the actions of an LR (1) parser for the input string ab+  (5 marks)