1) (50 points) Let \( G = \{T, N, S, P\} \) be a Context Free Grammar with \( T = \{a, b\} \), \( N = \{X\} \) and \( S = X \), and the production rules \( P \) are given by:

\[
X \rightarrow aXb | aX | \epsilon
\]

The symbol \( \epsilon \) indicates the empty string, i.e. it serves as a termination condition for the recursive rule.

\begin{enumerate}
  \item Give a brief description of the language generated by this grammar.
  \item Prove that \( G \) is an ambiguous grammar by finding an output of \( G \), which can be generated using two different parse trees. Draw the parse trees.
  \item Find an unambiguous grammar that recognizes the same language.
\end{enumerate}

2) (50 points) Some simple low level virtual machine instructions that could be used for operational semantics are given below.

\begin{verbatim}
ident = var
ident = ident + 1
ident = ident - 1
goto label
if var relop var goto label
\end{verbatim}

\begin{enumerate}
  \item Using the simple virtual machine instructions given above, write the do-while statement of java in terms of operational semantics.
  \item Using the simple virtual machine instructions given above, convert the following code piece to low level language instructions.
    \begin{verbatim}
    while(a<b)
    {
    c--; if(c<=0)
    while(b>c)
    b--;
    }
    \end{verbatim}
  \item Define a denotational semantics for the language of octal (base 8) numerals. Use the definition to find the value of “672 (mod 8)” in mod 10.
\end{enumerate}