1. Consider the following grammar G

   $S \rightarrow (\ L\ ) \mid \mathbf{a}$

   $L \rightarrow L\ ,\ S \mid S$

   where L and S are nonterminals and **a**, (,), and , are terminals.
   (a) [10] Rewrite G to G' to eliminate left recursion
   (b) [5] Write down the FIRST and FOLLOW sets for all nonterminals of G'
   (c) [10] Show the predictive parsing table of G'
   (d) [5] Show the process of parsing the string "(a, (a, a)) $" by the parser.

2. Consider the following grammar G:

   $S' \rightarrow S$

   $S \rightarrow A\mathbf{a} \mid \mathbf{b}A\mathbf{c} \mid \mathbf{Bc} \mid \mathbf{bBa}$

   $A \rightarrow \mathbf{d}$

   $B \rightarrow \mathbf{d}$

   where S', S, and A are nonterminals and **a**, **b**, **c**, and **d** are terminals.
   (a) [15] Is G LR(1)? If yes, give the parsing table. Otherwise, explain why.
   (b) [10] Is G LALR(1)? If yes, give the parsing table. Otherwise, explain why.

3. Consider the following grammar G:

   $S' \rightarrow S$

   $S \rightarrow \mathbf{i}E\mathbf{t}S \mid \mathbf{i}E\mathbf{t}S\mathbf{e}S \mid \mathbf{a}$

   $E \rightarrow \mathbf{b}$

   where S', S, and E are nonterminals and **i**, **t**, **e**, **a**, and **b** are terminals
   (a) [10] Please identify the conflicts in G
   (b) [5] Build the parse tree of the word **i***E***ti***E***t***S***e***S*** if shift action is chosen
   (c) [5] Build the parse tree of the word **i***E***ti***E***t***S***e***S*** if reduce action is chosen

4. Consider the following grammar G:

   S' → S

   S → (S) S | ϵ

   Construct an NFA N in which each state is an LR(0) item of G and:
   - There is a transition from $A \rightarrow \alpha \cdot X\ \beta$ to $A \rightarrow \alpha X \cdot \beta$ label X (X can be a nonterminal or terminal), and
   - There is a transition from $A \rightarrow \alpha \cdot B\ \beta$ to $B \rightarrow \cdot\ \gamma$ labeled ϵ

   (a) [10] Apply the subset construction algorithm to find all the subsets
   (b) [5] Construct the DAF D that recognizes the same languages as N
   (c) [10] Find the set of all sets of LR(0) items
   (d) [10] Write down the FIRST and FOLLOW sets for all nonterminals of G and show the SLR parsing table of G

5. Please answer the following questions based on your ***Go***$^-$ compiler project:
   (a) [5] Write down the first production and its action right after the first %% sign of your YACC program of project 3
   (b) [5] Write down the pattern and its action for the token **id** of your Lex program
   (c) [10] Suppose that we want to extend the ***Go***$^-$ programming language to support C-like **id++** and **++id** expressions. Please add productions and actions for the new expressions in your YACC such that appropriate Java bytecode can be generated.