Sample Questions for Midterm Exam

1. We considered the following phases in the compilation process: preprocessing, lexical analysis, syntax analysis (parsing), semantic analysis, code generation ( & improvement), linking.
   Describe, in a few sentences what is done in the semantic analysis phase and how it uses the result of the syntax analysis.

2. The alphabet for the following regular expression includes exactly the letters a, b, c. The parentheses indicate grouping, * indicates Kleene’s star.
   Consider the regular languages generated by the expressions
   \[ L_1 = a^*(b*a)^*c(a|b)^* \]
   \[ L_2 = (a*b)^*ac(a|b|c)^* \]
   Give a string in the language of \( L_1 \) but not in \( L_2 \)
   Give a string in the language of \( L_2 \) but not in \( L_1 \)

3. For this question assume that the alphabet is exactly the letters a, b, c. Give a regular expression that generates exactly the strings that have either exactly one a or at least 3 occurrences of b.

4. You are given the following grammar where the start symbol is S, upper case letters are non-terminals and lower case letters are terminals.

   \[ S \rightarrow ab \ X \ X \]
   \[ X \rightarrow c \ X \ | \ d \ Y \ Y \]
   \[ Y \rightarrow S \ | \ e \ Y \ | \ y \]

   Does the string abcd ey have a derivation?
   Does the string abd eab cde y y have a derivation?
   Does the string abcde y y dy y have a derivation?
   Assuming you answered yes for at least one of the above give the parse tree for the string.

5. You are given the following grammar where the start symbol is A, upper case letters are non-terminals and lower case letters are terminals and # is the empty string.

   \[ A \rightarrow x \ B \ C \ | \ y \ C \]
   \[ B \rightarrow b \ B \ | \ D \ | \ # \]
   \[ C \rightarrow c \]
   \[ D \rightarrow d \]

   (1) Compute the first sets for this grammar. (2) Compute the follow sets for this grammar. (3) Compute the predict sets for this grammar. (4) Can we construct a predictive parser for the grammar? explain your answer.

6. Repeat the previous question, replacing the rules for D with

   \[ D \rightarrow c \ | \ d \]

7. Typically programming languages utilize 3 kinds of memory allocation strategies: static, stack based, and heap based. Explain how the heap manager handles requests for allocation and deallocation of memory.
8. Briefly describe appropriate data structures and algorithm for implementing a symbol table for static scope.

9. Discuss the main ideas for compiling switch/case statements. Are they typically more efficient or less efficient than an equivalent if-else-if sequence? Why?

10. For each of the following ML expressions give the result and its type or in case there is an error explain what it is.

   if (true > false) then 10 else 100;

   let
     val x = (4, #"A", 5, "mid")
   in
     #4(x)
   end;

11. What is the type of the following ML function? Explain how the type can be inferred.

   fun f(a, b) = (size(b ^ "B") + 1, real(a+1));

12. Write a ML function \( \log_3 \) that take a positive integer input \( n \) and returns the integer \( d \) such that \( 3^d \leq n < 3^{d+1} \). (This is the integer part of the logarithm base 3 of \( n \).) So \( \log_3(7) \) returns 1, \( \log_3(25) \) returns 2, \( \log_3(28) \) returns 3, and \( \log_3(81) \) returns 4.