Sample Questions for Midterm Exam

1. Describe, in a few sentences what is done in the semantic analysis phase of compilation and how it uses the result of the syntax analysis.

2. 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 \(b\).

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

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

Does the string \(abcdey\) have a derivation?

Does the string \(abdeabcdeyy\) have a derivation?

Does the string \(abcdeyydyy\) have a derivation?

Assuming you answered yes for at least one of the above give the parse tree for the string.

4. 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.

5. What is a symbol table? Briefly describe what services a symbol table for dynamic scope needs to provide and how these can be implemented.

6. 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?

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

\[
\text{if (true > false) then 10 else 100;}
\]

\[
\text{let}
\quad \text{val x = (4,"A",5,"mid")}
\quad \text{in}
\quad \#4(x)
\quad \text{end;}
\]

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

\[
\text{fun f(a,b) = (size(b ^ "B") + 1, real(a+1));}
\]

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

\[
\text{fun f(a,b) = a :: hd(b) :: [] ;}
\]

10. Write a ML function \(\text{log3}\) 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 \(\text{log3}(7)\) returns 1, \(\text{log3}(25)\) returns 2, \(\text{log3}(28)\) returns 3, and \(\text{log3}(81)\) returns 4.
11. Write a function in ML that takes two sorted integer lists as input and produces a sorted merged list as illustrated by the following examples. The type of the function is:

```ml
val merge = fn : int list * int list -> int list
```

and when running the function with:

```ml
val a = merge([1,3,5],[2,3,6]);
val b = merge([10],[1,3,9]);
```

we get

```ml
val a = [1,2,3,3,5,6] : int list
val b = [1,3,9,10] : int list
```