**CS 3160 Concepts of Programming Languages**

**Fall 2018 Assignment 7**

**Due 12-7-2018**

1. Define in Lisp a function Find which takes two parameters, x and y. It returns x if x appears in y, and returns an empty list otherwise. Test your code for following test cases.

(find 'x '(1 3 (x y)))

(find 3 '(1 3 (x y)))

(find 2 '(1 3 (x y)))

2. Try evaluate the following lambda terms to their normal forms.

λ x. λ y. (λ z. z + 1) y

(λ f. λ x. f (f x)) (λ y. y+1)

(λ x. λ y. x y) y 3

3. Write a ML program to merge and sort two lists in descending order. Do not use any built in functions.

4. Show the three steps followed in ML type-inference algorithm by considering the following example.

fun quotient(x , y ) = x div y;

5. What is polymorphism? What are the different types of Polymorphism? Explain each one of them with a simple program.

6. Draw a pictorial snapshot of the runtime stack memory for the following ML code.

1: let val x=ref 2;

2: fun foo(y) = x := !x + y; y

3: in let val x = 5

4: in foo(x)

5: end

6: end;

7. What is tail recursion? Convert the following function to tail recursion.

fun find(x,[]) = 0 | find(x,y1::y2) = if (x = y1) then 1+ find(x,y2) else find(x,y2);

8. What is Object Oriented Programming? List all the OOPS concepts and explain each one of them.

9. Write a Python program to find the number of times a given letter occurs in each string recursively.

10. Draw the architecture of Java System. Write few lines about each part in the architecture.