CIS425 - Midterm Exam

Your Name : _____

Your Student ID : _____

(10 points) Consider the following grammar (where a and b are terminal symbols, and S is the root symbol):

$$\begin{array}{lcl} S & ::= & aSa \mid aBa \\ B & ::= & bB \mid b \end{array}$$

- What is the language generated by the above grammar?

- What kind of grammar is it? regular, context-free or context-sensitive? Briefly explain your answer.

(5 points) Give a context-free grammar for the language of balanced parenthesis (e.g. expressions of the form (), (()), (())((()())) etc.).

(5 points) Define in ML a **tail recursive** function that computes the length of a list.

(5 points) Using *only* the function defined below:

```
fun G F nil     y = y
 |  G F (x::xs) y = F (x, (G F xs y))
```

write a function `sum-list` which given a list of natural numbers (i.e. positive integers) returns the sum of all its elements. It should returns 0 if the list is empty. For example,

```
sum-list [1,2,3,4] = 10
```

Your `sum-list` function should only call function `G` with the appropriate parameters and should not be directly recursive.

(5 points) Using *only* the function defined below:

```
fun G F nil     y = y
 |  G F (x::xs) y = F (x, (G F xs y))
```

write a function `max-list` which given a list of integers returns the maximum of its elements. It should returns 0 if the list is empty.

```
max-list [9,2,23,7] = 23
```

Your `max-list` function should only call function `G` with the appropriate parameters and should not be directly recursive.

(5 points) Unlike Javascript, in ML one cannot write a list such as [1, true, "aa"]. How would you define a list containing integers, booleans and strings in ML, in such a way as to express the list above?

(10 points) Consider the following program fragment:

```
let val x = 3 in
  let fun f(y) = x + y in
    let val x = 5 in
         x + f(x)
    end
  end
end;
```

1. Under static scoping, what value does the above code return?

2. Under dynamic scoping, what value does the above code return?

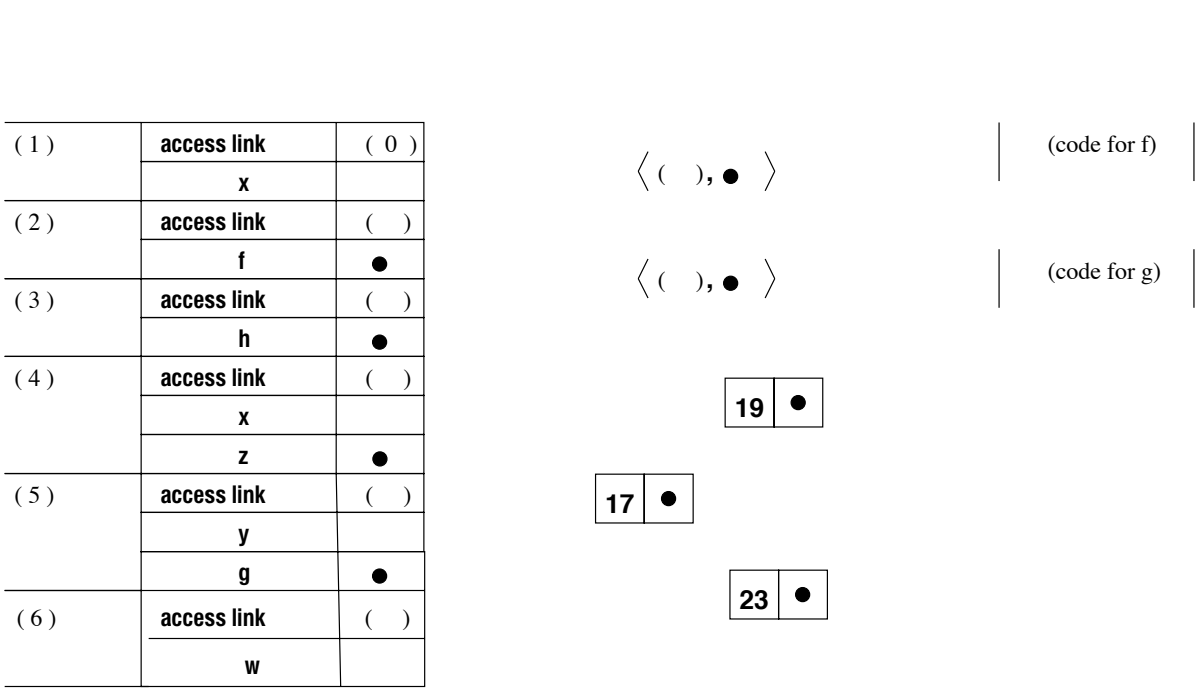
Memory Management

(10 points) Consider the following ML code:

```
val x = 5;
fun f(y) = let fun g(w) = w+x+y in g end;
val h = let val x=2
            val z = [17, 19, 23]
        in f(42) end;
h(x);
```

– What is the value of `h(x)`?

– Fill in the diagram below to complete the run-time stack as it appears immediately after the call to `h(x)`.



(15 points) Consider the following Algol-like program, write the number printed by running the program under each of the listed parameter passing mechanisms.

```
begin
 integer z ;

 procedure p (x);
  integer x; //type of the formal parameter
    begin
        x := x+1;
        z := z+2
    end

  z := 1;
  p(z);
  print z
end
```

(a) pass-by-value

(b) pass-by-reference

(c) pass-by-value-result