COMP 251: 2000 Fall Semester Midterm

Date:	Thursday, Oct 19, 1999
Time Allowed:	2 hours, 7-9pm
Instruction:	(a) There are total <u>SIX</u> questions.
	(b) Attempt <u>ALL</u> questions.
	(You may get partial credits for your incomplete answers!)
	(c) Write <u>ALL</u> answers in the blue book provided.

Problem 1 (14%) Consider the following grammar:

```
<S> ::= 0<S> | 1<A> | 0
<A> ::= 0<B> | 1<S> | 1
<B> ::= 0<A> | 1<B>
```

For each of the following strings, if it is in the language generated by `<S>`, draw a parse tree for it; if it is not in the language, explain why.

(a) (7%) 0110

(b) (7%) 11001

Problem 2 (20%) Consider the following table of some of the binary operators in C, in order of increasing precedence; that is, the assignment operator = has the lowest precedence and the additive operators have the highest precedence. The assignment operator is right associative; all the other operators are left associative. Write an expression grammar for these operators. Make sure that your grammar is unambiguous and handles precedence and associativity correctly. Assume here that `a`, `b`, and `c` are the tokens representing primitive expressions.

assignment	=
relational	== !=
additive	+ -

Problem 3 (16%) For the following C-like program using lexical scope rule, what is the printout after the call to Tricky(a, b) if the function parameters are passed using

(a) (4%) call-by-value?

(b) (4%) call-by-reference?

(c) (4%) call-by-value-result?

(d) (4%) call-by-name?

```
#include <iostream>

int a, b;

void Tricky(int i, int j) { a = i + j; b = a; }

int main()
{
    a = 4;
    b = 5;
    Tricky(a, b);
    cout << "a = " << a << " , b = " << b << endl;

    return 0;
}
```

Problem 4 (16%) Activation Record.

(a) (4%) What should an activation record for a typical programming language like Pascal contain? Answer the question by drawing a picture of such an activation record, showing the names of all its various fields.

(b) (4%) There are two links in the activation record you drew in part (a). Briefly explain the use of each link in 1 or 2 sentences.

(c) (8%) For the C program, "even_or_odd", below, draw the flow of activation records as they are created on the stack during execution of the program when it is called as "even_or_odd 3". I.e. show the sequence of snapshots of the stack of activation records at each time step when a procedure, including the main function, is activated or de-activated. Show clearly the various fields of each record: for each field, if you know its value, show its name and value, otherwise, show just its name. (Notice that the function atoi converts an ASCII string to an integer. Thus atoi("123") output 123.)

```
#include <stdlib.h>

bool Odd(int x); // Forward declaration of Odd

bool Even(int x) // Check if x is an even integer
{
    if (x == 0)
        return true;
    else if (x == 1)
        return false;
    else
        return Odd(x-1);
}

bool Odd(int x) // Check if x is an odd integer
{
    if (x == 0)
        return false;
    else if (x == 1)
        return true;
    else
        return Even(x-1);
}

int main(int argc, char* argv[])
{
    int j = atoi(argv[1]);
    Even(j);
    return 0;
}
```

Problem 5 (18%) Use the notations of the SML interpreter in our labs to answer the following questions.

(a) (4%) What is the type of each of the following ML expressions:

i. `[ [1, 2], nil, [3] ]`

ii. `( [true, false, true], (true, true), 0.5 )`

(b) (4%) Give <u>ONE</u> example for each of the following ML types:

i. `int list list list`

ii. `string list * (int * (real*string)) * bool`

(c) (10%) What is the type of function `H` in each of the following ML function definitions?

i. `fun H x = 4`

ii. `fun H(x, y) = x - y`

iii. `fun H(x, y, z) = x(y, z)`

iv. `fun H b c = c b`

Problem 6 (16%) SML Programming.

(a) (8%) The money you put into a bank earns compound interest according to the following formula:

$$Total = Principal \times (1 + r\%)^n$$

where n is the number of whole years your money is kept in the bank; $r\%$ is the yearly compound interest rate, *Principal* is the amount of money you deposit into the bank; and, *Total* is the total amount you will have after n years.

i. Write an ML function, total, to answer queries like: "If I deposit $1000 to a bank which offers a yearly compound interest of 10%, how much will I get back after 10 years?" You have to decide on the number and the type of arguments to the function, total.

ii. Using the SML notation, write down the type of function total in part (i).

You are not allowed to write additional (auxiliary) functions and there is no built-in power(x,y) function to compute e.g. x^y.

(b) (8%) The following table shows a database that we use to keep your comp251 records.

Name	Mark	Grade
Chan Man	70	B
Lee On	50	C
Wong Dan	90	A
...	...	...

i. How would you use an identifier, L, to represent the database in SML as a list?

ii. Suppose that you are given an ML function, search_by_name(x, y), which takes two arguments: a list representing the database (x) and a string argument representing the name of a student (y), and returns his/her record in the representation according to your answer in part (i). Write an ML expression to find out the mark of the student "Lee On".