

CS 3721: Programming Languages Lab

Lab #04: Programming in ML

ML is a statically typed functional programming language. In particular, ML is both compiled and interpreted. Similar to Scheme, it supports functional programming; similar to C/Pascal, it also supports statements and a wide variety of compound data structures including lists, tuples, records(similar to C struct), and user-defined data types.

If you have a ML program, say myprogram.ml, you can compile and run your program by typing

```
> sml < myprogram.ml
```

The redirection ensures that the ML environment reads your program, processes all the statements and expressions, and then exits. **NOTE: All ML statements must terminate with semicolons (“;”). ML will not start interpreting your expression unless you place a “;” at the end (which makes it a statement).**

Finish the following exercises to get you familiar with ML syntax and concepts. Open a text file with “.sml” as extension and save all your solutions. In particular, use a comment above each solution to indicate the corresponding exercise number. Each ML comment must be enclosed within a pair of (* and *).

```
(* This is a comment. sml will not attempt to execute any part of it. *)
```

After you are done, submit your sml file at

www.cs.utsa.edu/~cs3723

1. ML supports five types of atomic values: unit, bool, int, real, and string. Give an example for each type of values (when possible, different from the ones shown below).
`() ; (5+3)-2 ; 3.0 + 4.2 ; 5 = 4 ; "abc" ;`
2. ML provides three operations to support bool values: andalso, orelse, and not. Given an example that uses each operator (different from the ones shown below).
`3 = 3 andalso 2 = 2 ; not (3 = 2 orelse 2 = 2) ;`
3. ML provides five operations to support int values: +, -, *, div, mod; The operations for supporting real values are +, -, *, /. Note that / can be used for dividing floating point values only. Give an integer and a real expression that use the above operators respectively (different from the ones shown below). What happens when you mix integer and real values?
`2 + 3 * 5 - 2 div 1 + 5 mod 2 ; 2.15 * 5.0 - 2.1 / 3.1 + 3.5 ;`
4. The ^ operator is provided to support string concatenation. Given an example for the operator (different from the ones shown below).
`"abc" ^ "def" ;`
5. ML supports the following types of compound values: list, tuple, record, function, and

reference (similar to C pointers). Give an example for each type of values (different from the ones shown below).

```
1::[2,3,4]; (3,4); {f1 = "a", f2="b"}; fn x => x + 5; ref 3;
```

6. What operations can be used to build a list, test whether a list is empty, and pull apart values in the list? Give an example for each operation (different from the examples given below).

```
null []; hd (2 :: [3, 4, 5]); tl(2 :: [3,4,5]);
```

7. What operations can be used to build a tuple and to pull apart values in a tuple? Give an example for each operation (different from the examples given below).

```
(3,4); #1(3,4); #2(3,4);
```

8. What operations can be used to build a record and to pull apart values in a record? Give an example for each operation (different from the examples given below).

```
{f1 = "a", f2="b"};  
#f1{f1 = "a", f2="b"}; #f2{f1 = "a", f2="b"};
```

9. What operations can be used to build a function and to invoke a function with arguments? Give an example for each operation (different from the examples given below).

```
fn x => x + 5; (fn x => x + 5) 6;
```

10. What operations can be used to build a reference cell (similar to a C pointer), to modify a reference cell, and to extract the value of a reference cell? Give an example for each operation (different from the examples given below).

```
val x = ref 3; x := 5; !x;
```

11. How to define new variables in ML? (val, fun) Give two examples different from the examples given below.

```
val t = (1, 2, 3); val (x,y,z) = t; fun plus(x,y) = x + y;
```

12. How to define new data types in ML? Give an example of a user-defined union type (different from the one below) and give a value of your user-defined type.

```
datatype MyType = TypeInt of int | TypeFloat of real | Unit; TypeFloat(2.3);
```

13. What control-flow operations are supported in ML? (if-then-else, while) Give an example for each operation together with the result of evaluation (different from the ones show below).

```
if true then 1 else 5;  
val x = ref 0; while (!x < 5) do x := !x + 1;
```