

## 1997 Paper 2 Question 1

**Twenty-part question** (*One mark per part*)

(a) Give some ML text to replace `<insert>` in the following:

```
<insert>
fun f g g = g; f x y;
```

to make it into a valid ML program.

(b) Given the following ML function definition:

```
fun h x y z = x (y z);
```

what is the type of `h`?

(c) Let  $A$  be the set  $\{1, 2, 3, 4\}$ . Exhibit (or state briefly why this is impossible) a relation  $R$  on  $A$  which is a function whose inverse relation  $R^{-1}$  is a partial function, but not a (total) function.

(d) Solve the recurrence

$$\begin{aligned}f(0) &= 0 \\f(1) &= 3 \\f(n+2) &= 6f(n+1) - 9f(n)\end{aligned}$$

## 1997 Paper 2 Question 1 (continued)

- (e) It is claimed that there is a bijection from  $(A+B) \rightarrow C$  to  $(A \rightarrow C) \times (B \rightarrow C)$ . Demonstrate this by replacing both “...” below with valid ML code which might form such a bijection and its inverse. Just ML is required, not proof.

```
datatype BplusS = left of bool | right of string;
fun LtoR(f: BplusS -> real)
  : (bool->real) * (string->real)
  = ...;
fun RtoL((g: bool->real), (h: string->real))
  : (BplusS -> real)
  = ...;
```

- (f) Give an equation involving a set named  $S$ , such that the smallest (with respect to  $\subseteq$ ) solution for  $S$  is the set of values represented by the ML datatype  $s$ :

```
datatype s = empty | leaf of int | branch of s*s;
```

Your solution may reasonably involve the constructors `empty`, `leaf` and `branch`.

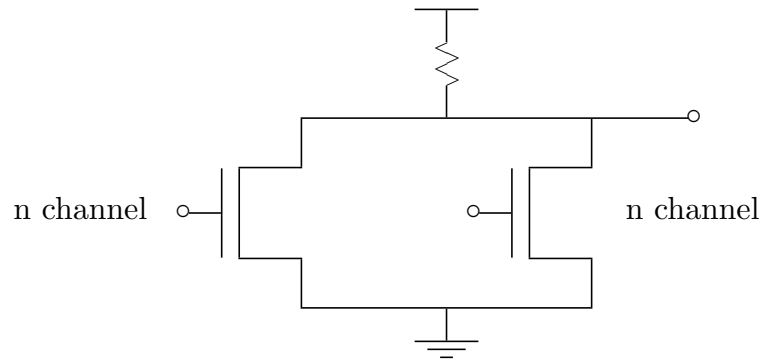
- (g) Given an integer value between 0 and 9, show an expression in Modula-3 for the equivalent character.
- (h) What output would the following Modula-3 fragment produce when P was called?

```
PROCEDURE P () =
  PROCEDURE Q (VAR a: INTEGER) =
    BEGIN a := 2 * a + b END Q;
  VAR a := 1; b := 2; c := 3;
  BEGIN
    Q (c);
    IO.Put (Fmt.Int (a) & "\n");
    IO.Put (Fmt.Int (b) & "\n");
    IO.Put (Fmt.Int (c) & "\n");
  END P;
```

- (i) What is meant by an *address space*?
- (j) How are operating system services invoked?

# 1997 Paper 2 Question 1 (continued)

(k) What is this?



(l) What is the minimum sum of product form for the function specified by the following map in which X indicates *don't care*?

|     |     |   |   |   |     |
|-----|-----|---|---|---|-----|
|     | $a$ |   |   |   |     |
| $c$ | X   | X | X | X | $d$ |
|     | X   | 1 | 1 | 1 |     |
|     | 1   | 1 | 1 | X |     |
|     | X   | X | X | X |     |
|     | $b$ |   |   |   |     |

- (m) Identify at least one other factor involved in computer security beyond technical measures such as provision of password access.
- (n) Name *two* branches of the law under which software ownership can be protected.
- (o) Provide a generating function  $G(\eta)$  that is suitable for a random variable which is distributed Geometric( $p$ ).
- (p) Given that  $P(X=0) = P(Y=0) = \frac{1}{4}$  and that  $P(X=0 \cap Y=0) = \frac{1}{8}$ , determine  $P(X \neq 0 \cap Y \neq 0)$ .
- (q) Describe the way in which Regular Expressions are constructed.
- (r) How does the minimum time in which a large software project can be completed depend on the number of staff allocated to it?

## 1997 Paper 2 Question 1 (continued)

- (s) Give in binary a pair of five-bit numbers which when added give the correct result when considered as unsigned integers but which overflow when considered as two's complement numbers.
- (t) What is meant by *top-down* programming and how does it differ from *bottom-up* programming?