

## 1999 Paper 7 Question 12

### Types

Contrast the advantages and disadvantages of explicit and implicit typing. [4 marks]

Consider an ML-style language with types and type schemes

$$\begin{aligned}\tau &::= \alpha \mid \mathbf{bool} \mid \tau \rightarrow \tau \mid \tau \mathbf{list} \\ \sigma &::= \forall A(\tau)\end{aligned}$$

Give the typing rules for variables, function abstraction, function application, and let-binding. Make the form of the typing judgement clear. [5 marks]

Give terms  $M_1$  and  $M_2$  such that  $N_1$  is typable (in the empty context) and  $N_2$  is not, where

$$\begin{aligned}N_1 &\stackrel{\text{def}}{=} \mathbf{let\ val\ } f = M_1 \mathbf{in\ } M_2 \mathbf{end} \\ N_2 &\stackrel{\text{def}}{=} (\mathbf{fn\ } f \Rightarrow M_2) M_1\end{aligned}$$

Give all uses of  $\sigma \succ \tau$  required in a typing derivation for  $N_1$ ; prove that there does not exist a typing derivation for  $N_2$ . [7 marks]

What is a *principal type scheme*? Give the principal type scheme for  $N_1$ , or explain informally why it does not have one. [4 marks]