

2002 Paper 7 Question 13

Types

- (a) State the typing rule for ML **let**-expressions, **let** $x = M$ **in** M' , using typing judgements of the form $A, \Gamma \vdash M : \tau$ where A is a finite set of type variables, Γ is a finite function from variables to type schemes and τ is a type. [3 marks]
- (b) Give an example to show that in a **let**-expression **let** $x = M$ **in** M' , the **let**-bound variable x can occur polymorphically in the body M' . Give the proof of any valid typing judgement that you use. [5 marks]
- (c) Give the ML typing rules for the unit value $()$, for reference creation **ref** M , for dereferencing $!M$, and for assignment $M := M'$. [4 marks]
- (d) Explain how the combination of the typing rules from parts (a) and (c) leads to unsoundness of the type system. How does the revised definition of ML modify the typing rule for **let**-expressions in order to restore type soundness? [8 marks]