13 Types (AMP)

(a) Give the rules for typing the ML expressions for function abstraction and application, reference creation, dereferencing and assignment. [5 marks]

(b) What is the value-restricted form of the typing rule for let-expressions in ML? Briefly explain what is the purpose of imposing the value restriction on the typing rule. [5 marks]

(c) Which of the following typing judgements are provable in the ML type system with the value-restricted typing rule for let-expressions? Justify your answer in each case.

(i) \{\} ⊢ \text{let } r = \text{ref } (\lambda x \text{ true}) \text{ in } (r := \lambda z \text{ true}) : \text{unit}

(ii) \{\} ⊢ \text{let } r = \text{ref } (\lambda x \text{ true}) \text{ in } (!r (\lambda y (r := \lambda z \text{ true}))) : \text{unit}

(iii) \{\} ⊢ \text{let } r = (\lambda x (\lambda y (x))) \text{true in } r (\text{ }) : \text{bool}

(iv) \{\} ⊢ \text{let } r = \lambda y \text{true in } r (\text{ }) : \text{bool}

[10 marks]