(a) Explain the use of the following when representing circuits in logic:

(i) higher-order variables; [2 marks]

(ii) conjunction ($\land$); [2 marks]

(iii) existential quantification ($\exists$). [2 marks]

(b) Describe a representation of binary words in logic and define a function that maps a word to the natural number it encodes in binary. [2 marks]

(c) Describe how the following components are modelled in higher-order logic:

(i) unit-delay; [2 marks]

(ii) clocked, edge-triggered D-type register. [2 marks]

(d) Let $[t, t']$ denote the closed interval starting at $t$ and ending at $t'$ ($t \leq t'$ and both $t$ and $t'$ are included in the interval). Give definitions in higher-order logic of the predicates

(i) $\text{Stable}$

(ii) $\text{Odd}$

where: $\text{Stable } f (t, t')$ is true if and only if the value of $f$ is constant on the interval $[t, t']$ and $\text{Odd } f (t, t')$ is true if and only if $f$ is true an odd number of times in the interval $[t, t']$. [2 + 4 marks]

(e) Contrast the simple switch model of transistors with the difference switching model. [2 marks]