CS 421 Midterm **Name:**_____

Rules for type derivations:

Constants:

$$\frac{}{\Gamma \vdash n : \text{int}}$$ (assuming n is an integer constant)

$$\frac{}{\Gamma \vdash \text{true} : \text{bool}} \qquad \frac{}{\Gamma \vdash \text{false} : \text{bool}}$$

Variables:

$$\frac{}{\Gamma \vdash x : \sigma} \quad \text{if } \Gamma(x) = \sigma$$

Primitive operators ($\oplus \in \{ +, -, *, \ldots \}$):

$$\frac{\Gamma \vdash e_1 : \text{int} \quad \Gamma \vdash e_2 : \text{int}}{\Gamma \vdash e_1 \oplus e_2 : \text{int}}$$

Relations ($\sim \in \{ <, >, =, <=, >= \}$):

$$\frac{\Gamma \vdash e_1 : \text{int} \quad \Gamma \vdash e_2 : \text{int}}{\Gamma \vdash e_1 \sim e_2 : \text{bool}}$$

Connectives :

$$\frac{\Gamma \vdash e_1 : \text{bool} \quad \Gamma \vdash e_2 : \text{bool}}{\Gamma \vdash e_1 \,\&\&\, e_2 : \text{bool}} \qquad \frac{\Gamma \vdash e_1 : \text{bool} \quad \Gamma \vdash e_2 : \text{bool}}{\Gamma \vdash e_1 \,||\, e_2 : \text{bool}}$$

If_then_else rule:

$$\frac{\Gamma \vdash e_1 : \text{bool} \quad \Gamma \vdash e_2 : \tau \quad \Gamma \vdash e_3 : \tau}{\Gamma \vdash (\text{if } e_1 \text{ then } e_2 \text{ else } e_3) : \tau}$$

Application rule:

$$\frac{\Gamma \vdash e_1 : \tau_1 \to \tau_2 \quad \Gamma \vdash e_2 : \tau_1}{\Gamma \vdash (e_1\ e_2) : \tau_2}$$

fun rule:

$$\frac{[x : \tau_1] + \Gamma \vdash e : \tau_2}{\Gamma \vdash \text{fun } x \text{ -> } e : \tau_1 \to \tau_2}$$

let rule:

$$\frac{\Gamma \vdash e_1 : \tau_1 \quad [x : \tau_1] + \Gamma \vdash e_2 : \tau_2}{\Gamma \vdash (\text{let x} = e_1 \text{ in } e_2) : \tau_2}$$

let rec rule:

$$\frac{[x: \tau_1] + \Gamma \vdash e_1 : \tau_1 \quad [x: \tau_1] + \Gamma \vdash e_2 : \tau_2}{\Gamma \vdash (\text{let rec x} = e_1 \text{ in } e_2) : \tau_2}$$