1. Determine which of the following statements is true after one step of evaluation using Small-Step (Transition) Semantics.

   (a) $\langle$`while x > 5 do x := x - 1 od`$, \{x := 10\}\rangle$
   $\longrightarrow$ $\langle$`while x > 5 do x := x-1 od`$, \{x := 9\}\rangle$

   False

   (b) $\langle$`while x > 5 do x := x - 1 od`$, \{x := 10\}\rangle$
   $\longrightarrow$ $\langle$`x := x - 1; while x > 5 do x := x - 1 od`$, \{x := 10\}\rangle$

   True

   (c) $\langle$`while x > 5 do x := x - 1 od`$, \{x := 10\}\rangle$
   $\longrightarrow$ $\langle$`x := x - 1`$, \{x := 10\}\rangle$

   False

   (d) $\langle$`while x > 5 do x := x - 1 od`$, \{x := 10\}\rangle$
   $\longrightarrow$ $\langle$`while x > 5 do x := x - 1 od`$, \{x := 10\}\rangle$

   False

2. Determine which of the following statements is true after one step of evaluation using Small-Step (Transition) Semantics.

   (a) $\langle$`if x > 10 then x := 10 else skip`$, \{x \mapsto 11\}\rangle$
   $\longrightarrow$ $\langle$`x > 10`$, \{x \mapsto 11\}\rangle$

   False

   (b) $\langle$`if x > 10 then x := 10 else skip`$, \{x \mapsto 11\}\rangle$
   $\longrightarrow$ $\langle$`skip`$, \{\}\rangle$

   True

   (c) $\langle$`while x < 5 do x := x - 1 od`$, \{x \mapsto 10\}\rangle$
   $\longrightarrow$ $\langle$`E`$, \{x \mapsto 10\}\rangle$

   True

   (d) $\langle$`while true do x := 5 od`$, \{\}\rangle$
   $\longrightarrow$ $\langle$`x := 5; while true do x := 5 od`$, \{\}\rangle$

   True

3. Complete the proof below.

$$\dfrac{\dfrac{\dfrac{}{(\texttt{x}, \{x \mapsto 4\}) \Downarrow 4}\ \texttt{Var} \quad \dfrac{}{(\texttt{5}, \{x \mapsto 4\}) \Downarrow 5}\ \texttt{Int}}{(\texttt{x > 5}, \{x \mapsto 4\}) \Downarrow \mathit{false}}\ \texttt{RelOp} \quad \dfrac{\dfrac{\dfrac{}{(\texttt{x}, \{x \mapsto 4\}) \Downarrow 4}\ \texttt{Var} \quad \dfrac{}{(\texttt{3}, \{x \mapsto 4\}) \Downarrow 3}\ \texttt{Int}}{(\texttt{x * 3}, \{x \mapsto 4\}) \Downarrow 12}\ \texttt{BinOp}}{(\texttt{y := x * 3}, \{x \mapsto 4\}) \Downarrow \{x \mapsto 4, y \mapsto 12\}}\ \texttt{Asgn}}{(\texttt{if x > 5 then y := x * 5 else y := x * 3 fi}, \{x \mapsto 4\}) \Downarrow \{x \mapsto 4, y \mapsto 12\}}\ \texttt{If}$$

4. Complete the proof below.

$$\dfrac{\dfrac{}{(\texttt{x}, \{x \mapsto 4\}) \Downarrow 4} \quad \dfrac{}{(\texttt{5}, \{x \mapsto 4\}) \Downarrow 5}}{(\texttt{x < 5}, \{x \mapsto 4\}) \Downarrow \mathit{true}}\ \texttt{RelOp} \quad \dfrac{\dfrac{\dfrac{}{(\texttt{x}, \{x \mapsto 4\}) \Downarrow 4} \quad \dfrac{}{(\texttt{1}, \{x \mapsto 4\}) \Downarrow 1}}{(\texttt{x + 1}, \{x \mapsto 4\}) \Downarrow 5}\ \texttt{BinOp}}{(\texttt{x := x + 1}, \{x \mapsto 4\}) \Downarrow \{x \mapsto 5\}}\ \texttt{Asgn} \quad \dfrac{}{(\texttt{x}, \{x \mapsto 5\}) \Downarrow 5}\ \texttt{Var}}{(\texttt{y := x}, \{x \mapsto 5\}) \Downarrow \{x \mapsto 5, y \mapsto 5\}}\ \texttt{Asgn}}{(\texttt{x := x + 1; y := x}, \{x \mapsto 4\}) \Downarrow \{x \mapsto 5, y \mapsto 5\}}\ \texttt{Seq} \quad \dfrac{\dfrac{\dfrac{}{(\texttt{x}, \{x \mapsto 5; y \mapsto 5\}) \Downarrow 5}\ \texttt{Var} \quad \dfrac{}{(\texttt{5}, \{x \mapsto 5; y \mapsto 5\}) \Downarrow 5}\ \texttt{Int}}{(\texttt{x < 5}, \{x \mapsto 5; y \mapsto 5\}) \Downarrow \mathit{false}}\ \texttt{RelOp}}{(\texttt{while x < 5 do x := x + 1; y := x od}, \{x \mapsto 5; y \mapsto 5\}) \Downarrow \{x \mapsto 5, y \mapsto 5\}}\ \texttt{While}$$

$$(\texttt{while x < 5 do x := x + 1; y := x od}, \{x \mapsto 4\}) \Downarrow \{x \mapsto 5, y \mapsto 5\}\ \texttt{While}$$

5. Given the following Hoare Logic statement, fill in the blanks appropriately.

$$\{\ \boxed{\text{A}}\ \}\ \texttt{x := x * 2;}\ \{\ \boxed{\text{B}}\ \}\ \texttt{y := y * 2}\ \{x = 10; y = 20\}$$

   (a) The box for A should be filled in with: $x := 5; y := 10$

   (b) The box for B should be filled in with: $x := 10; y := 10$

6. Given the following Hoare Logic statement, fill in the blanks appropriately.

$$\{\ \boxed{\ldots}\ \}\ \texttt{if x > 0 then}\ \{\ \boxed{\text{A}}\ \}\ \texttt{x := x * 2}\ \{x > 10\}$$
$$\texttt{else}\ \{\ \boxed{\text{B}}\ \}\ \texttt{x := -x}\ \{x > 10\}\ \texttt{fi}\ \{\ \boxed{\ldots}\ \}$$

   (a) The box for A should be filled in with: $x > 5$

   (b) The box for B should be filled in with: $x < -10$