This assignment contains 3 questions, for a total of 20 points.

1. (5 pts) Consider the big-step operational semantics defined in class. Show the entire derivation tree for deriving $\langle \text{if } x > y \text{ then } y := x + y \text{ else } y := x - y, \sigma \rangle \rightarrow \sigma'$ where $\sigma(x) = 7$, $\sigma(y) = 2$, $\sigma'(x) = 7$, $\sigma'(y) = 9$.

2. (10 pts) Which of the following results (i.e., Hoare triples) are valid?

   (a) $\{ \text{true} \} x := 2 \{ \text{true} \}$
   (b) $\{ \text{true} \} x := x \{ \text{false} \}$
   (c) $\{ \text{false} \} x := 2 \{ \text{true} \}$
   (d) $\{ \text{false} \} x := 2 \{ \text{false} \}$
   (e) $\{ \text{true} \} \text{while true do } x := 2 \{ \text{false} \}$
   (f) $\{ \text{true} \} x := x + 1 \{ x = x + 1 \}$
   (g) $\{ x = y \} t := x; \ x := y; \ y := t \{ x = y \}$
   (h) $\{ x >= 0 \} x := y \{ y >= 0 \}$
   (i) $\{ x = 0 \} \text{while } x < 10 \text{ do } x := x - 1 \{ x = x + 1 \}$
   (j) $\{ x = 0 \} \text{while } x < 10 \text{ do } x := x + 1 \{ x = x + 1 \}$

3. (5 pts) Consider the following valid triple

   $\{ \text{true} \}
   \quad \text{if } x>y \text{ then } z:=(y-x)-1 \text{ else } z:=(x-y)-1;
   \quad z:=1-12*z
   \quad \{ z>=10 \}$

Show the entire derivation tree for deriving this triple, using the axiomatic semantics rules discussed in class. The “bottom” (i.e. root) of the tree should be this triple. A leaf of the tree is either (1) a triple that can be directly derived from an axiom, or (2) an implication $\alpha \Rightarrow \beta$ used in the rule of consequence. You must show explicitly all implications $\alpha \Rightarrow \beta$ you have used when applying the rule of consequence.