Exercise 1: Indicate in a sentence or two how much time you spent on this homework, how difficult you found it subjectively, and what you found to be the hardest part. Tell me something about yourself that I do not already know. Any non-empty answer will receive full credit.

Also, if your opinions have changed since the last assignment, indicate one thing you like about the class so far and one thing you would change about it.

Exercise 2: Prove that for any command $c$ and any assertion $A$, we can construct a derivation for

$$\vdash \{A\} c \{\text{true}\}$$

Do not prove this statement by using weakest preconditions or by invoking the completeness of the Hoare rules. You may assume that for any assertion $A$, we can construct a derivation for $\vdash A \Rightarrow \text{true}$.

Exercise 3: In class, we gave the following rules for the (backward) verification condition generation of assignment and let:

$$
\begin{align*}
\text{vc}(c_1; c_2, B) & \triangleq \text{vc}(c_1, \text{vc}(c_2, B)) \\
\text{vc}(x := e, B) & \triangleq [e/x]B \\
\text{vc}\text{(let } x = e \text{ in } c, B) & \triangleq [e/x]\text{vc}(c, B)
\end{align*}
$$

The above rule for \texttt{let} has a bug. Give a correct rule for \texttt{let}.

Exercise 4: Given $\{A\} c \{B\}$, recall that we desire that

$$A \Rightarrow \text{vc}(c, B) \Rightarrow \text{wp}(c, B)$$

holds. We say that our vc rules are sound if

$$\models \{\text{vc}(c, B)\} c \{B\}.$$ 

Explain briefly why the buggy \texttt{let} rule is unsound and demonstrate the unsoundness of the rule by giving the following six things:
1. a command $c$,
2. a post-condition $B$,
3. a state $\sigma$, and
4. a state $\sigma'$ such that
5. $\sigma \models \text{vc}(c, B)$ and
6. $\langle c, \sigma \rangle \downarrow \sigma'$ but
7. $\sigma' \not\models B$.

Exercise 5: Give the (backward) verification condition rule for the command

\[
\text{do}_{\text{Inv}} c \text{ while } b
\]

with respect to a post-condition $B$. The invariant $\text{Inv}$ is true before and after $c$ is executed. Your answer may not be defined in terms of $\text{vc(while ...)}$. 