[Ex. 1] Consider the IMP program

\[ w \overset{\text{def}}{=} \textbf{while } \neg(x = 0) \lor \neg(y = 0) \textbf{ do } (x := x - 1; y := y - 1) \]

Define the set of stores \( T = \{ \sigma \mid \ldots \} \) for which the program \( w \) terminates and:

1. prove formally that for any store \( \sigma \in T \) we have \( \langle w, \sigma \rangle \rightarrow \sigma[0/x, 0/y] \).
   (Hint: use well-founded induction on \( T \))

2. prove formally (by using the rule for divergence seen during the course) that \( \langle w, \sigma \rangle \not\rightarrow \) for any store \( \sigma \notin T \).

[Ex. 2] Consider the HOFL term:

\[ t \overset{\text{def}}{=} \textbf{rec } f. \lambda x. \lambda y. \textbf{if } x \times y \textbf{ then } x \textbf{ else } (fx)((fx)y) \]

Derive the type, the canonical form and the denotational semantics of \( t \).

[Ex. 3] Consider the CCS agents:

\[ p \overset{\text{def}}{=} (\textbf{rec } x. a.x) \vert \textbf{rec } x. b.x \quad q \overset{\text{def}}{=} \textbf{rec } x. a.a.x + a.b.x + b.a.x + b.b.x \]

Prove that \( p \) and \( q \) are strongly bisimilar or exhibit an HM-logic formula \( F \) that can be used to distinguish them.

[Ex. 4] Given the \( \mu \)-calculus formula:

\[ \phi \overset{\text{def}}{=} \nu x.(p \lor \lozenge x) \land (q \lor \Box x) \]

compute its denotational semantics and evaluate it on the LTS below:

\[
\begin{array}{c}
S_1 \quad S_2 \quad S_3 \quad q \\
S_4 \quad S_5 \quad S_6 \quad p
\end{array}
\]