1. [2 points] Using the fixed point method, give the set of states of the following transition system satisfying the CTL formula \( E[q \ U \ EGAFp] \).

2. [1 point] Give a definition in LTL of the F, G, R, and W operators using only the U operator and the Boolean connectives.

3. [1 point] Write a CTL formula for each of the following sentences:
   a) it is possible to return to a state where property \( p \) holds;
   b) it is always possible to return to a state where property \( p \) holds.

4. [2 points] The command \( \text{repeat} \{ \ c \} \text{ until } b \) is intended to execute the command \( c \) repeatedly until the condition \( b \) is false. Give the rules for defining its formal operational semantics.

5. [1 point] Give the formal definitions of validity for partial and total correctness of an Hoare triple \( \{ \phi \} c \{ \psi \} \).

6. [1 point] For each of the following cases, give a command \( c \) that satisfies the following Hoare triples for total correctness:
   a) \( \{ \text{false} \} c \{ \text{false} \} \)
   b) \( \{ \text{true} \} c \{ \text{false} \} \)
   c) \( \{ \text{true} \} c \{ \text{true} \} \).

7. [2 points] Give a proof outline for the total correctness of the following Hoare triple

\[
\{ 0 \leq y \} \\
z := 1 ; \\
a := 0 ; \\
\text{while } a \neq y \text{ do} \\
\quad z := z \times x ; \\
\quad a := a + 1 \\
\text{od} \\
\{ z = x^y \}
\]

The final score is given by the sum of the points obtained.