Question 1. For each of the following LTL properties, draw an NBW automaton describing it. If possible make it a DBW.

1. \(GFp\)
2. \(FGq\)
3. \(GFa \land GFb\)
4. \(a \rightarrow X[bUc]\)

Question 2. For each of the following pairs of LTL/PSL properties. Prove or refute (i) whether \(\varphi_1\) implies \(\varphi_2\) and (ii) whether \(\varphi_2\) implies \(\varphi_1\). You can refute by drawing a waveform on which one is satisfied and the other one is not. (iii) If the properties are not equivalent can you propose a minimal change to one of them to make them equivalent?

1. \(\varphi_1 = GFp \land GFq\) \(\varphi_2 = GF(p \land q)\)
2. \(\varphi_1 = FGp \land GFq\) \(\varphi_2 = FG(p \land q)\)
3. \(\varphi_1 = (a \land X b) \rightarrow X[cUd]\) \(\varphi_2 = (a \cdot b) \implies (c^* \cdot d)\)
4. \(\varphi_1 = G(a \cdot b \cdot c)\) \(\varphi_2 = (a \cdot b \cdot c) \land ((a \cdot b \cdot c)^+ \implies (a \cdot b \cdot c))\)
5. \(\varphi_1 = (aUb)\) \(\varphi_2 = \text{true} \implies (a^* \cdot b)\)
6. \(\varphi_1 = (aWb)\) \(\varphi_2 = \text{true} \implies (a^* \cdot b)\)

Question 3. State the following properties in (i) QPTL (ii) S1S (iii) PSL and (iv) if possible also in LTL.

1. \(p\) holds on every third cycle and \(q\) holds on every sixth cycle
2. \(p\) holds on an even cycle iff \(q\) does not hold on that cycle
3. \(p\) holds at the 3rd occurrence of \(q\) and never again
4. \(p\) holds at the last occurrence of \(q\) and onwards
5. \(p\) oscillates (that is \(p\) changes its value infinitely often)
6. every data transaction (sequence starting with datastart and ending with dataend in which sending holds all along) is followed by an ack signal in the next cycle or the cycle after that.