1. Check whether the following are equivalent: for any formula $P$ and $Q$

(a) $P \models Q$

(b) If $\models P$ then $\models Q$

2. Establish whether the following formulas are valid in Intuitionistic Logic $IL$:

(a) $¬(A \land ¬A)$

(b) $(¬A \rightarrow A) \rightarrow A$

In case they are valid in $IL$ provide a Natural Deduction proof. Otherwise, exhibit a Kripke countermodel and a sequent calculus proof.

3. Is the following statement:

• $Q(x) \rightarrow \forall x P(x) \equiv \forall x (Q(x) \rightarrow P(x))$

true? (exhibit either a proof or a counterexample)

4. Show that the formula $¬(\forall x A(x) \lor ¬\forall x A(x))$ is unsatisfiable.