1. Suppose you are trying to prove some formula \( C \). What is something you could “safely” do right away (i.e., might not help, but definitely won’t hurt), if you have the assumption
   - \( A \land B \)?
   - \( A \lor B \)?

2. We say that a formula is a \textit{stacking} formula if it is equivalent to a conjunction, and a \textit{splitting} formula if it is equivalent to a disjunction.\(^1\) Which of the following formulas are splitting and which are stacking?
   - \( A \rightarrow B \)
   - \( \neg(A \land B) \)
   - \( \neg(A \lor B) \)
   - \( \neg(A \rightarrow B) \)
   - \( \neg\neg A. \) (This is neither. But how could we simplify it?)

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\(^1\)Equivalent in a nontrivial way, of course, since any formula \( A \) satisfies \( A \equiv A \land \top \equiv A \lor \bot \).
3. A (classical logic) tableau proof is arranged as follows:

- We start with the premises and the negation of the conclusion, and try to prove $\bot$. So, it's always a proof by contradiction.
- We build a tree (creating and extending paths) by splitting or stacking; once a formula is split or stacked we can “check it off” and ignore it thereafter.
- A path from the root is closed if it contains a contradiction (i.e., both $r$ and $\neg r$); we stop extending this path.
- The process stops with success if all paths are closed. (If we get stuck before all paths close, we can use the open path(s) to derive a counterexample.)

Give tableau proofs for:

- $p \rightarrow q \rightarrow p$

- $(p \lor q) \land \neg q \rightarrow p$
• \( (p \rightarrow q) \rightarrow (\neg q \rightarrow \neg p) \)

• \( ((p \rightarrow q) \rightarrow p) \rightarrow p \)
• \(((p \rightarrow q) \land (\neg p \rightarrow q)) \rightarrow q\)

• \(((p \rightarrow q) \rightarrow r) \rightarrow (p \rightarrow (q \rightarrow r))\)
• \(((w \rightarrow m) \land (x \rightarrow a)) \rightarrow ((x \rightarrow m) \lor (w \rightarrow a))\)

4. What splitting/stacking/simplifying can we do in a tableau proof with:
   • \(\exists x. P(x)\)
   • \(\forall x. P(x)\)
   • \(\neg\exists x. P(x)\)
   • \(\neg\forall x. P(x)\)
5. Give a tableau proof for:

- ∀x. P(x) ⊢ ¬∃x. ¬P(x).

- ∃z. ∀w. Q(z, w) ⊢ ∀y. ∃x. Q(x, y)