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1. (1 point) Conjunctive normal form (CNF) is not a canonical representation. Give two formulae in CNF that are equivalent but not (syntactically) identical. You are not supposed to use the commutativity property, that is, $\varphi_1 \wedge \varphi_2$ and $\varphi_2 \wedge \varphi_1$ would be treated as identical.

2. (1 point) Show that $\varphi \equiv (\neg p \wedge \neg q) \vee (\neg q \wedge p \wedge r)$ and $\psi \equiv \neg((p \rightarrow r) \rightarrow q)$ are logically equivalent.

3. Let $*$ be a new operator such that $p * q$ does *not* hold iff p and q are either both false or both true.
   (a) (1 point) Write down the truth table for $p * q$.
   (b) (1 point) Write down the truth table for $(p * p) * (q * q)$.

4. (2 points) Prove by resolution that $((p \rightarrow q) \wedge (q \rightarrow p)) \rightarrow ((p \wedge q) \vee (\neg p \wedge \neg q))$ is a valid formula.

5. (2 points) Consider the following clauses: $c_1 = \neg p \vee q \vee t$, $c_2 = \neg p \vee \neg t$, $c_3 = r \vee s$, $c_4 = \neg r \vee s$, and $c_5 = \neg q \vee \neg s$. With p as the root, draw the implication graph. If it is a conflicting graph, list all the unique implication points. Otherwise, give a satisfying assignment to the conjunction of the clauses.

6. (2 points) Construct the binary decision diagram compositionally (bottom-up) for $\varphi \equiv (a \oplus b) \wedge c \rightarrow d$ where $\oplus$ is XOR. Use $a < b < c < d$ as the variable order from the top to the bottom.