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Tutorials for Decision Procedures
Exercise Sheet 1

Exercise 1: The NOR Connective — 4 Points

The logical connective $\downarrow$ ("nor") has the following truth table:

F_1	F_2	$F_1 \downarrow F_2$
0	0	1
0	1	0
1	0	0
1	1	0

(a) Prove that $\top$, $\bot$ and the standard logical connectives $\neg$, $\wedge$, $\vee$, $\rightarrow$, and $\leftrightarrow$ can be represented by $\downarrow$.
Hint: Start with $\neg$ and $\vee$.

(b) Give an algorithm that transforms any propositional formula into NOR normal form, i.e. a formula containing only propositional variables, parentheses and $\downarrow$.

Exercise 2: Validity and Satisfiability — 4 Points

Which of the following formulae is valid, which is satisfiable?
If a formula is valid or unsatisfiable, give a proof via a truth table or a semantic argument. Otherwise, give a satisfying and a falsifying interpretation.

(a) $P \rightarrow (Q \rightarrow P)$

(b) $P \vee \neg P \wedge Q$

(c) $(P \rightarrow (Q \rightarrow R)) \rightarrow (P \rightarrow R)$

(d) $(\neg P \vee \neg Q \vee R) \wedge (\neg P \vee Q) \wedge P \wedge \neg R$

Exercise 3: Negation Normal Form — 4 Points

Convert the following formulae into Negation Normal Form (NNF) using the template equivalences from the lecture.

(a) $P \rightarrow (Q \rightarrow R)$

(b) $\neg(P \rightarrow Q) \vee (P \wedge Q)$

(c) $(P \wedge Q \rightarrow (Q \vee R)) \wedge (\neg P \rightarrow R)$

(d) $P \leftrightarrow (P \vee Q)$