# Epp Theorem 1.1.1 Logical Equivalences

Given any statement variables $P$, $Q$, and $R$, a tautology $\mathbf{t}$, and a contradiction $\mathbf{c}$, the following logical equivalences hold.

(1) Commutative laws:

$$\begin{aligned} P \wedge Q &\equiv Q \wedge P \\ P \vee Q &\equiv Q \vee P \end{aligned}$$

(2) Associative laws:

$$\begin{aligned} P \wedge (Q \wedge R) &\equiv (P \wedge Q) \wedge R \\ P \vee (Q \vee R) &\equiv (P \vee Q) \vee R \end{aligned}$$

(3) Distributive laws:

$$\begin{aligned} P \wedge (Q \vee R) &\equiv (P \wedge Q) \vee (P \wedge R) \\ P \vee (Q \wedge R) &\equiv (P \vee Q) \wedge (P \vee R) \end{aligned}$$

(4) Identity laws:

$$\begin{aligned} P \wedge \mathbf{t} &\equiv P \\ P \vee \mathbf{c} &\equiv P \end{aligned}$$

(5) Negation laws:

$$\begin{aligned} P \vee \neg P &\equiv \mathbf{t} \\ P \wedge \neg P &\equiv \mathbf{c} \end{aligned}$$

(6) Double negation law:

$$\neg(\neg P) \equiv P$$

(7) Idempotent laws:

$$\begin{aligned} P \wedge P &\equiv P \\ P \vee P &\equiv P \end{aligned}$$

(8) Universal bound laws:

$$\begin{aligned} P \vee \mathbf{t} &\equiv \mathbf{t} \\ P \wedge \mathbf{c} &\equiv \mathbf{c} \end{aligned}$$

(9) DeMorgan's laws:

$$\begin{aligned} \neg(P \wedge Q) &\equiv \neg P \vee \neg Q \\ \neg(P \vee Q) &\equiv \neg P \wedge \neg Q \end{aligned}$$

(10) Absorption laws:

$$\begin{aligned} P \vee (P \wedge Q) &\equiv P \\ P \wedge (P \vee Q) &\equiv P \end{aligned}$$

(11) Negations of $\mathbf{t}$ and $\mathbf{c}$:

$$\begin{aligned} \neg\mathbf{t} &\equiv \neg\mathbf{c} \\ \mathbf{c} &\equiv \mathbf{t} \end{aligned}$$