

R. (8 points)

Prove the following;

(a) $\vdash \perp \vee \psi \leftrightarrow \psi$,

(b) $\vdash (\phi \rightarrow \psi) \leftrightarrow (\neg\phi \vee \psi)$,

(c) $\vdash (\phi \vee \psi) \leftrightarrow (\neg\phi \rightarrow \psi)$,

(d) $\vdash \phi \vee \psi \leftrightarrow \neg(\neg\phi \wedge \neg\psi)$,

(e) $\vdash \phi \wedge \psi \leftrightarrow \neg(\neg\phi \vee \neg\psi)$,

(f) $\vdash \neg\phi \leftrightarrow (\phi \rightarrow \perp)$,

(g) $\vdash \perp \leftrightarrow \phi \wedge \neg\phi$,

(h) $\vdash (\phi \leftrightarrow \psi) \leftrightarrow ((\phi \rightarrow \psi) \wedge (\psi \rightarrow \phi))$.