LOGIC FOR PHILOSOPHY

1 Chapter one

2 Chapter two

2.1 Disjunction and equivalence

(a) We need to show that for any wff φ and χ, and any PL-interpretation $\mathscr{I}$, $V_{\mathscr{I}}(\varphi \vee \chi)$=1 iff either $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1. We must first notice that $(\varphi \vee \chi)$ is just shorthand for $(\sim \varphi \rightarrow \chi)$, so that what we need to show is that for any wff φ and χ, and any PL-interpretation $\mathscr{I}$, $V_{\mathscr{I}}(\sim \varphi \rightarrow \chi)$=1 iff either $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1. This can be done by showing, first, that, if $V_{\mathscr{I}}(\sim \varphi \rightarrow \chi)$=1 then $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1, and subsequently that, if $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1 then $V_{\mathscr{I}}(\sim \varphi \rightarrow \chi)$=1.

Let us start by proving that if $V_{\mathscr{I}}(\sim \varphi \rightarrow \chi)$=1, then either $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1. We first assume that $V_{\mathscr{I}}(\sim \varphi \rightarrow \chi)$=1. Recall that we have defined the valuation function for $\rightarrow$ as follows: $V_{\mathscr{I}}(\phi \rightarrow \psi)$=1 iff either $V_{\mathscr{I}}(\phi)$=0 or $V_{\mathscr{I}}(\psi)$=1. Given our assumption, we can therefore say that either $V_{\mathscr{I}}(\sim \varphi)$=0 or $V_{\mathscr{I}}(\chi)$=1. But then, given the definition for the valuation function for $\sim$, which is $V_{\mathscr{I}}(\sim \phi)$=1 iff $V_{\mathscr{I}}(\phi)$=0, we can say that either $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1. This is what we wanted to show.

The second stage of the proof requires us to prove that if $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1 then $V_{\mathscr{I}}(\sim \varphi \rightarrow \chi)$=1. So, let us assume that either $V_{\mathscr{I}}(\varphi)$=1 or $V_{\mathscr{I}}(\chi)$=1. By the valuation function for $\sim$, we see how our assumption implies that ei-

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ther $V_{\mathscr{I}}(\sim \varphi)$=0 or $V_{\mathscr{I}}(\chi)$=1. And so, subsequently, by the valuation function for $\rightarrow$, we can demonstrate that our assumption implies that $V_{\mathscr{I}}(\sim \varphi \rightarrow \chi)$=1. □

(b) We need to show that for any wff φ and χ, and any PL-interpretation $\mathscr{I}$, $V_{\mathscr{I}}(\varphi \leftrightarrow \chi) = 1$ iff $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$. We begin by noting that $\phi \leftrightarrow \psi$ is shorthand for $(\phi \rightarrow \psi) \wedge (\psi \rightarrow \phi)$, and that the latter in its turn is shorthand for $(\sim (\phi \rightarrow \psi) \rightarrow \sim (\psi \rightarrow \phi))$. This means that what we need to show is that, for any wff φ and χ, and any PL-interpretation $\mathscr{I}$, $V_{\mathscr{I}}(\sim ((\phi \rightarrow \chi) \rightarrow \sim (\chi \rightarrow \phi))) = 1$ iff $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$. This can be done by showing, first that, if $V_{\mathscr{I}}(\sim ((\phi \rightarrow \chi) \rightarrow \sim (\chi \rightarrow \phi))) = 1$ then $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$, and, subsequently, that if $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$, then $V_{\mathscr{I}}(\sim ((\phi \rightarrow \chi) \rightarrow \sim (\chi \rightarrow \phi))) = 1$.

Let us start by proving that if $V_{\mathscr{I}}(\sim ((\phi \rightarrow \chi) \rightarrow \sim (\chi \rightarrow \phi))) = 1$ then $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$. We proceed by reductio, and so start by assuming that $V_{\mathscr{I}}(\phi) \neq V_{\mathscr{I}}(\chi)$. This allows us to assume that, say, $V_{\mathscr{I}}(\phi) = 1$ and that $V_{\mathscr{I}}(\chi) = 0$. Recall that we have defined the valuation function for $\rightarrow$ as follows: $V_{\mathscr{I}}(\phi \rightarrow \psi) = 1$ iff either $V_{\mathscr{I}}(\phi) = 0$ or $V_{\mathscr{I}}(\psi) = 1$. The converse of this is that $V_{\mathscr{I}}(\phi \rightarrow \psi) = 0$ iff $V_{\mathscr{I}}(\phi) = 1$ and $V_{\mathscr{I}}(\psi) = 0$. We see that our assumptions about the valuation interpretation for ψ and χ imply that $V_{\mathscr{I}}(\phi \rightarrow \chi) = 0$. We now introduce the further assumption that $V_{\mathscr{I}}(\sim ((\phi \rightarrow \chi) \rightarrow \sim (\chi \rightarrow \phi))) = 1$, which is just the antecedent of the conditional we are trying to prove. By the definition of the valuation function of $\sim$, we see that $V_{\mathscr{I}}((\phi \rightarrow \chi) \rightarrow \sim (\chi \rightarrow \phi)) = 0$. But if we again rely on our definition of the valuation function of $\rightarrow$, we can demonstrate that $V_{\mathscr{I}}(\phi \rightarrow \chi) = 1$ (and that $V_{\mathscr{I}}(\sim (\chi \rightarrow \phi)) = 0$). But we have already demonstrated that $V_{\mathscr{I}}(\phi \rightarrow \chi) = 0$, and so we have a contradiction. This allows us to reject the assumption that $V_{\mathscr{I}}(\phi) \neq V_{\mathscr{I}}(\chi)$, and so we have shown that $V_{\mathscr{I}}(\sim ((\phi \rightarrow \chi) \rightarrow \sim (\chi \rightarrow \phi))) = 1$ then $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$.

Now we still need to prove that if $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$, then

$V_{\mathscr{I}}(\sim((\phi \to \chi) \to\sim(\chi \to \phi))) = 1$. We assume that $V_{\mathscr{I}}(\phi) = V_{\mathscr{I}}(\chi)$, and so can assume that either $V_{\mathscr{I}}(\phi) = 1$ and that $V_{\mathscr{I}}(\chi) = 1$, or that $V_{\mathscr{I}}(\phi) = 0$ and that $V_{\mathscr{I}}(\chi) = 0$. We proceed in two straightforward stages.

First, we demonstrate that if we assume $V_{\mathscr{I}}(\phi) = 1$ and that $V_{\mathscr{I}}(\chi) = 1$, it follows that $V_{\mathscr{I}}(\sim((\phi \to \chi) \to\sim(\chi \to \phi))) = 1$. We assume that $V_{\mathscr{I}}(\phi) = 1$ and that $V_{\mathscr{I}}(\chi) = 1$. Using our definitions for the valuation function of $\to$ and $\sim$, we can say that $V_{\mathscr{I}}(\phi \to \chi) = 1$ and that $V_{\mathscr{I}}(\sim(\chi \to \phi)) = 0$. But this implies that $V_{\mathscr{I}}((\phi \to \chi) \to\sim(\chi \to \phi)) = 0$, which in turn implies that $V_{\mathscr{I}}(\sim((\phi \to \chi) \to\sim(\chi \to \phi))) = 1$. This is the desired result.

Second, we demonstrate that if we assume $V_{\mathscr{I}}(\phi) = 0$ and that $V_{\mathscr{I}}(\chi) = 0$, it equally follows that $V_{\mathscr{I}}(\sim((\phi \to \chi) \to\sim(\chi \to \phi))) = 1$. Again, the valuation function of $\to$ and $\sim$ allow us to say that $V_{\mathscr{I}}(\phi \to \chi) = 1$ and that $V_{\mathscr{I}}(\sim(\chi \to \phi)) = 0$. As shown, this implies that $V_{\mathscr{I}}((\phi \to \chi) \to\sim(\chi \to \phi)) = 0$, which in turn implies that $V_{\mathscr{I}}(\sim((\phi \to \chi) \to\sim(\chi \to \phi))) = 1$. □

3 Logical consequence

(a) We need to establish that $\vDash [P \wedge (Q \vee R)] \to [(P \wedge Q) \vee (P \wedge R)]$. We can prove this by reductio. So let $\mathscr{I}$ be any PL-interpretation, and let us assume that $V_{\mathscr{I}}((P \wedge (Q \vee R)) \to ((P \wedge Q) \vee (P \wedge R))) = 0$. Given our definition of the valuation function $\to$, we can say that (*i*) $V_{\mathscr{I}}(P \wedge (Q \vee R)) = 1$, and that (*ii*) $V_{\mathscr{I}}((P \wedge Q) \vee (P \wedge R)) = 0$. Given our definitions of the valuation function $\wedge$ and $\vee$, we can say that (*iii*) $\mathscr{I}(P) = 1$ (from (*i*)), and that (*iv*) $V_{\mathscr{I}}(P \wedge Q) = 0$ (from (*ii*)), and so that (*v*) $\mathscr{I}(P) = 0$ (from (*ii*)). We have now derived a contradiction from our assumption (*iii* & *v*), and so $V_{\mathscr{I}}((P \wedge (Q \vee R)) \to ((P \wedge Q) \vee (P \wedge R))) = 1$.

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(b) We need to establish that $(P \leftrightarrow Q) \vee (R \leftrightarrow S) \nvDash P \vee R$

(c)