

# Assignment #3

## CIS 427/527

Group 2

January 26, 2016

### 1

Show that the following propositions are derivable:

(a)  $\varphi \rightarrow \varphi$

$$\frac{[\varphi]^1}{\varphi \rightarrow \varphi} \rightarrow I^1$$

(b)  $\perp \rightarrow \varphi$

$$\frac{\frac{[\perp]^1}{\varphi} \perp E}{\perp \rightarrow \varphi} \rightarrow I^1$$

(c)  $\neg(\varphi \wedge \neg\varphi)$

$$\frac{\frac{[\varphi \wedge \neg\varphi]_1}{\varphi} \wedge E \quad \frac{[\varphi \wedge \neg\varphi]_1}{\neg\varphi} \wedge E}{\frac{\perp}{\neg(\varphi \wedge \neg\varphi)} \rightarrow I^1} \text{EFQ}$$

(d)  $(\varphi \rightarrow \psi) \leftrightarrow \neg(\varphi \wedge \neg\psi)$

Incomplete

$$\frac{\frac{\frac{\perp}{\neg(\varphi \wedge \neg\psi)} \text{RAA}}{(\varphi \rightarrow \psi) \rightarrow \neg(\varphi \wedge \neg\psi)} \rightarrow I \quad \frac{\varphi \rightarrow \psi}{\neg(\varphi \wedge \neg\psi) \rightarrow (\varphi \rightarrow \psi)} \rightarrow I}{(\varphi \rightarrow \psi) \leftrightarrow \neg(\varphi \wedge \neg\psi)} \rightarrow I$$

(e)  $(\varphi \wedge \psi) \leftrightarrow \neg(\varphi \rightarrow \neg\psi)$

$$\frac{\frac{\frac{[\varphi \wedge \psi]_1}{\psi} \wedge E \quad \frac{[\varphi \wedge \psi]_1}{\varphi} \wedge E}{\frac{\perp}{\neg(\varphi \rightarrow \neg\psi)} \rightarrow I^2} \rightarrow I^1 \quad \frac{\frac{[\neg\psi]^2}{\varphi \rightarrow \neg\psi} \text{RAA}^2}{\frac{\perp}{\varphi \wedge \psi} \wedge I^1} \rightarrow I}{(\varphi \wedge \psi) \leftrightarrow \neg(\varphi \rightarrow \neg\psi)} \rightarrow I$$

(f)  $\varphi \rightarrow (\psi \rightarrow (\varphi \wedge \psi))$

$$\frac{\frac{[\varphi]^1}{\varphi \wedge \psi} \wedge I \quad \frac{[\psi]^2}{\psi \rightarrow (\varphi \wedge \psi)} \rightarrow I^2}{\varphi \rightarrow (\psi \rightarrow (\varphi \wedge \psi))} \rightarrow I^1$$

## 2

Show that the following propositions are derivable:

(a)  $(\varphi \rightarrow \neg\varphi) \rightarrow \neg\varphi$

$$\frac{\frac{\frac{[\varphi \rightarrow \neg\varphi]_1}{\neg\varphi} \rightarrow E \quad [\varphi]_2}{[\varphi]_2} \rightarrow E}{\frac{\frac{\perp}{\neg\varphi} \rightarrow I^2}{(\varphi \rightarrow \neg\varphi) \rightarrow \neg\varphi} \rightarrow I_1}$$

(b)  $[\varphi \rightarrow (\psi \rightarrow \sigma)] \leftrightarrow [\psi \rightarrow (\varphi \rightarrow \sigma)]$

$$\frac{\frac{\frac{[\psi \rightarrow (\varphi \rightarrow \sigma)]_3}{\varphi \rightarrow \sigma} \rightarrow E \quad [\psi]_1}{\frac{\sigma}{\psi \rightarrow \sigma} \rightarrow I^1} \rightarrow E \quad [\varphi]_2}{\frac{\frac{\sigma}{\psi \rightarrow \sigma} \rightarrow I^1}{\varphi \rightarrow (\psi \rightarrow \sigma)} \rightarrow I^2} \rightarrow I^3 \quad \frac{\frac{[\varphi \rightarrow (\psi \rightarrow \sigma)]_3}{\psi \rightarrow \sigma} \rightarrow E \quad [\varphi]_1}{\frac{\frac{\sigma}{\varphi \rightarrow \sigma} \rightarrow I^1}{\psi \rightarrow (\varphi \rightarrow \sigma)} \rightarrow I^2} \rightarrow E \quad [\psi]_2}{\frac{\frac{\sigma}{\varphi \rightarrow \sigma} \rightarrow I^1}{\psi \rightarrow (\varphi \rightarrow \sigma)} \rightarrow I^2} \rightarrow I^3} \rightarrow I^3$$

$$\frac{[\psi \rightarrow (\varphi \rightarrow \sigma)] \rightarrow [\varphi \rightarrow (\psi \rightarrow \sigma)] \rightarrow I^3 \quad [\varphi \rightarrow (\psi \rightarrow \sigma)] \rightarrow [\psi \rightarrow (\varphi \rightarrow \sigma)] \rightarrow I^3}{[\varphi \rightarrow (\psi \rightarrow \sigma)] \leftrightarrow [\psi \rightarrow (\varphi \rightarrow \sigma)]}$$

(c)  $(\varphi \rightarrow \psi) \wedge (\varphi \rightarrow \neg\psi) \rightarrow \neg\varphi$

(d)  $(\varphi \rightarrow \psi) \rightarrow [(\varphi \rightarrow (\psi \rightarrow \sigma)) \rightarrow (\varphi \rightarrow \sigma)]$

$$\frac{\frac{[\varphi \rightarrow \psi]_1}{\psi} \rightarrow E \quad [\varphi]_2}{\psi} \rightarrow E \quad \frac{[\varphi]_2 \quad [(\varphi \rightarrow (\psi \rightarrow \sigma))]_3}{\psi \rightarrow \sigma} \rightarrow E$$

$$\frac{\frac{\frac{\sigma}{\varphi \rightarrow \sigma} \rightarrow I_2}{(\varphi \rightarrow (\psi \rightarrow \sigma)) \rightarrow (\varphi \rightarrow \sigma)} \rightarrow I_3}{(\varphi \rightarrow \psi) \rightarrow [(\varphi \rightarrow (\psi \rightarrow \sigma)) \rightarrow (\varphi \rightarrow \sigma)]} \rightarrow I_1$$

## 3

Show:

(a)  $\varphi \vdash \neg(\neg\varphi \wedge \psi)$

$$\frac{\frac{[\neg\varphi \wedge \psi]_1}{\neg\varphi} \wedge E \quad \varphi}{\frac{\perp}{\neg(\neg\varphi \wedge \psi)} \rightarrow I_1} \rightarrow E$$

(b)  $\neg(\varphi \wedge \neg\psi), \varphi \vdash \psi$

(c)  $\neg\varphi \vdash (\varphi \rightarrow \psi) \leftrightarrow \neg\varphi$

(d)  $\vdash \varphi \Rightarrow \vdash \psi \rightarrow \varphi$

(e)  $\neg\varphi \vdash \varphi \rightarrow \psi$

$$\frac{\frac{[\varphi]_1 \quad \neg\varphi}{\perp} \rightarrow E}{\frac{\psi}{\varphi \rightarrow \psi} \rightarrow I_1} \text{EFQ}$$