PHIL3110 - Assignment 1

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Part A

Problem 1

1. $$\dfrac{\dfrac{Pa \lor Qa^{(1)} \qquad (Pa \lor Qa) \to \bot}{\bot}}{\neg(Pa \lor Qa)}\ (1)\ (\neg I)$$

2. $$\dfrac{\dfrac{Qa \lor Ra^{(3)} \qquad \dfrac{Qa^{(1)} \qquad Qa \to Pa}{Pa} \qquad \dfrac{Ra^{(2)} \qquad Ra \to Pa}{Pa}}{Pa}\ (1)\ (2)\ (\lor E)}{(Qa \lor Ra) \to Pa}\ (3)\ (\to I)$$

Problem 2

1.
$$Q^{\mathcal{M}} = \{m_1\}$$
$$T^{\mathcal{M}} = \{\langle m_1, m_1\rangle, \langle m_1, m_2\rangle, \langle m_2, m_2\rangle\}$$

2. Distressingly, $\mathcal{L}$ does not define any constant symbols, nor does $\mathcal{M}$ provide interpretations of constant symbols in $\mathcal{M}$.

   Thus

$$\mathcal{M} \not\models \exists x\, \neg Txx$$

   However assuming $\mathcal{M}^+$, where $\mathcal{M}^+$ is the expanded model $\mathcal{M}$, where $m^{\mathcal{M}} = m$ for all $m \in M$, we see that

$$M \models \exists x\, \neg Txx$$

   as

$$\langle m_3^{\mathcal{M}}, m_3^{\mathcal{M}}\rangle \notin T^{\mathcal{M}}$$

3. No, as $\mathcal{M}$ does not define any constant symbols $\mathcal{M} \not\models \exists x\, \varphi$ for some arbitrary φ (as x will bind no constant symbols), and thus

$$\mathcal{M} \not\models \exists x \forall y\, (Qy \leftrightarrow Tyx)$$

   Assuming $\mathcal{M}^+$,

$$\mathcal{M}^+ \not\models \exists x \forall y\, (Qy \leftrightarrow Tyx)$$

   By fixing x to $m_1^{\mathcal{M}}$, we see that

$$\forall y \cdot y \in Q^{\mathcal{M}} \leftrightarrow \langle y, m_1^{\mathcal{M}}\rangle \in T^{\mathcal{M}}$$

as

$$m_1^{\mathcal{M}} \in Q^{\mathcal{M}} \text{ and } \langle m_1^{\mathcal{M}}, m_1^{\mathcal{M}} \rangle \in T^{\mathcal{M}}$$
$$m_2^{\mathcal{M}} \notin Q^{\mathcal{M}} \text{ and } \langle m_2^{\mathcal{M}}, m_1^{\mathcal{M}} \rangle \notin T^{\mathcal{M}}$$
$$m_3^{\mathcal{M}} \notin Q^{\mathcal{M}} \text{ and } \langle m_3^{\mathcal{M}}, m_1^{\mathcal{M}} \rangle \notin T^{\mathcal{M}}$$

Part B

Problem 3

1. (a) $BHMB$ is not a good sandwich
   (b) $(((B)JB)HB)$ is a good sandwich
   (c) $BHBMBJM$ is not a good sandwich

2. DEFINITION
   A sandwich is good iff there is some stage n such that $\mathit{sandwich} \in \mathit{Stage}(n)$ where:
   - $\mathit{Stage}(0) = \{B\}$
   - $\mathit{Stage}(n+1)$ is the set of φ such that either:
     (a) $\varphi \in \mathit{Stage}(n)$
     (b) φ is of the form ψMB, ψHB, or ψJB, where $\psi \in \mathit{Stage}(n)$

3. Make A the set of all n such that for each $\psi \in \mathit{Stage}(n)$, ψ does not contain any two instances of the same ingredient adjacently.

   (BASE) $0 \in A$. As $\mathit{Stage}(0) = \{B\}$, all $\varphi \in \mathit{Stage}(0)$ do not contain any two instances of the same ingredient adjacently. We can also see that all $\varphi \in \mathit{Stage}(0)$ are terminated by B

   (INDUCTION STEP) Suppose $n \in A$. Since $n \in A$, and every $\varphi \in \mathit{Stage}(n)$ is of the form B, ψMB, ψHB, or ψJB, for $\psi \in \mathit{Stage}(m)$ for some $m < n$, all φ are terminated by B.

   For each $\varphi \in \mathit{Stage}(n+1) \setminus \mathit{Stage}(n)$, recalling the definition for $\mathit{Stage}(n+1)$, φ is of the form ψMB, ψHB, or ψJB, for some $\psi \in \mathit{Stage}(n)$.

   Given

   - all $\varphi \in \mathit{Stage}(n)$ are terminated by B
   - all $\varphi \in \{MB, HB, JB\}$ don't begin with B, and are not themselves adjacent ingredients
   - since $n \in A$, every $\varphi \in \mathit{Stage}(n)$ does not contain any two instances of the same ingredient adjacently

   all $\varphi \in \mathit{Stage}(n+1) \setminus \mathit{Stage}(n)$ do not contain two instances of the same ingredient adjacently.

   Thus, $n+1 \in A$. Then by induction, we see that every $n \in A$.