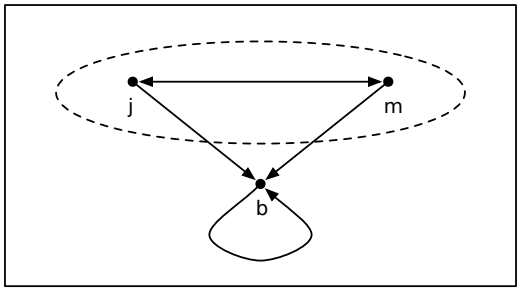
2.1 Consider the following formula:

(1) $\forall x(R(P)(x) \rightarrow P(x))$

What types must P and R have for the formula to be well formed? Assume that x is a variable of type e.

2.2 Is it possible to have type theoretic expressions A and B such that both A(B) and B(A) are well-formed?

2.3 The diagram graphically represents a model structure $M = \langle U, V \rangle$ with a universe consisting of John, Bill, and Mary. The dashed line indicates the set of students, the arrow indicates the helping relation.



Give the value assignment function V_M for the following non-logical constants:

(a) john', bill', mary' $\in CON_e$

(b) student' $\in CON_{\langle e,t \rangle}$

(c) help' $\in CON_{\langle e,\langle e,t \rangle \rangle}$

2.4 Compute the denotations of the following expressions relative to the model structure from 2.3 and some variable assignment g. x is a variable of type e, and F is a variable of type $\langle e, t \rangle$.

(a) $[\![\text{help'(bill')(mary')}]\!]^{M,g} = ?$

(b) $[\![\lambda x.\neg \text{student'}(x)]\!]^{M,g} = ?$

(c) $[\![\forall x(\text{help'}(x)(x) \rightarrow \neg \text{student'}(x)]\!]^{M,g} = ?$

(d) $[\![\forall F \exists x F(x)]\!]^{M,g} = ?$

2.5 The lecture slides give lambda terms for some noun phrases such as "every student" or "Bill." Give corresponding lambda terms for the following:

(a) exactly one student

(b) every student except Mary

(c) only Bill

Give also representations for the complex determiner "exactly one."

2.6 Extend the sample grammar from the lecture with a syntax rule and a corresponding translation rule for (prenominal) adjectives. Compute a semantic representation for the sentence "a blond student works." Beta-Reduce the result as far as possible.

2.7 Bonus. Show that $\lambda x[\forall y \text{ know'}(x)(y)](y)$ and $\forall y \text{ know}(y)(y)$ are not equivalent.