1. The first part of this lab is just about manipulating expressions in the $\lambda$-calculus, without actually attaching them to grammatical rules (3 marks for each part).

   (a) Use the $\lambda$-calculus to write an expression which would produce $\text{exists}(X, \text{sleep}(X) \& \text{agent}(X, j))$ if you applied it to the term $j$.

   (b) Use the lambda-calculus to write an expression which would produce $\text{exists}(X, \text{sleep}(X) \& \text{agent}(X, j))$ if you applied the term the term $\lambda(P, P:j)$ to it.

   (c) Use the lambda-calculus to write an expression which would produce $\text{exists}(X, \text{man}(X) \& \text{exists}(Y, \text{agent}(Y, X) \& \text{sleep}(Y)))$ if you applied it to the term $\lambda(Z, \text{exists}(Y, \text{agent}(Y, Z) \& \text{sleep}(Y)))$.

   (d) Use the lambda-calculus to write an expression which would produce $\text{exists}(X, \text{man}(X) \& \text{exists}(Y, \text{agent}(Y, X) \& \text{sleep}(Y)))$ if you applied it to the answer for (1c).

2. The second part involves looking at and commenting on the logical forms that are produced by a small annotated grammar. Setting an exercise to write such a grammar is too challenging as a lab—if I just set an exercise to annotate rules as given in the lecture notes, then all you could do is copy out the notes, which isn’t very enlightening, but anything more will just be too difficult. More useful to give a number of problematic cases, particularly ones where there is an ambiguity present, and ask you to explain the source of the ambiguity and to choose which reading makes more sense.

?- [setup], setup(lab4).

as before, and then do for instance

| ?- analyse([john, ran, a, small, shop, in, berlin, '.'], M), pretty(M), fail.

Remember: names must begin with lower case letter—john rather than John—and sentences must end with ‘.’—it’s the full stop that tells us that we’ve got a complete utterance, which we need to know in order to get the interpretation right. The call of pretty will print M reasonably legibly (some of these are quite big, so you need them laid out as nicely as possible), and the fail will force the parser to generate all possible interpretations.

As we’ve seen in the lectures, there are different kinds of lexical ambiguity. Some of them arise because there are different parse trees, some because a single written form has multiple
interpretations, and some because the quantifiers can have different ‘scopes’. The point of this exercise is to identify which kind(s) of ambiguity arise in the various cases. For each example there will be interpretations that make sense, and there may be ones that don’t. There may also be several interpretations that actually describe the same state of affairs. For each analysis, you should say whether it makes sense and whether it is the same as one of the others. You should show your marker a file with the outputs of the program for each example with each output annotated in terms of whether it makes sense; whether it describes the same state of affairs as one of the others; and whether the difference between it and the others is caused because there is a structural ambiguity, or because some word has multiple meanings, or because the words and the syntactic structure are simply not enough to determine the meaning.

(1) John ran a small shop in Berlin.
(2) She ran a marathon in Berlin in four hours.
(3) Hob believes a witch stole his cow.
(4) She bought it for four pounds.

Write a brief explanation of the sources of ambiguity in each case and of the way the various interpretations differ, and if possible explain why one analysis is to be preferred over another: 2 marks for each.