Phrase Structure Rules
S → NP (Aux) VP
CP → (C) S
NP → Det N'
N' → N
N' → Adj N'
N' → N' PP
VP → V NP* PP* (CP)
VP → VP PP
PP → P NP

Question 1
Draw a tree for each of the following sentences.

a. A man with a red hat talked to John on Tuesday.
b. John bought a red cake with white icing.

c. John said that a woman with blue eyes in a grey coat saw Mary.
Question 2  [6 points]
Suppose we replace the phrase structure rule in (i) (taken from the list at the beginning of this homework) with the rule in (ii):

(i) \[ N' \rightarrow N' \text{ PP} \]
(ii) \[ N' \rightarrow N \text{ PP} \quad (N' \text{ has been replaced by } N \text{ on the right of the arrow}) \]

Show that replacing (i) with (ii) leads to undergeneration. That is, show that there are acceptable English sentences which can be generated using (i) together with the other phrase structure rules, but which cannot be generated using (ii).

Question 3  [5 points]
Consider the following extensions to our grammar of English designed to permit sentences (A-C):

(A)  John picked up the book.
(B)  John put down the apple.
(C)  John threw out the garbage.

First, we modify the VP rule to permit lone prepositions to follow the verb:

\[ VP \rightarrow V \left( P \right) \text{ NP* PP* (CP)} \]

And add the following subcategorization frames:
picked \_ \_ up NP
put \_ \_ down NP
throw \_ \_ out NP

Write a transformation rule that enables the generation of sentences (A’-C’) without further modification of the phrase structure rules:

(A’) John picked the book up.
(B’) John put the apple down.
(C’) John threw the garbage out.