Readings: AIMA Chapter 23 (Sections 1-3)

1. Given the following grammar:

\[
S \Rightarrow NP \ VP \\
NP \Rightarrow Noun \ | \ Article \ Noun \ | \ NP \ PP \ | \ Noun \ Noun \\
VP \Rightarrow Verb \ | \ VP \ NP \ | \ VP \ PP \\
PP \Rightarrow Preposition \ NP \\
Article \Rightarrow the \\
Noun \Rightarrow agent \ | \ wumpus \ | \ [1,2] \\
Verb \Rightarrow detects \\
Preposition \Rightarrow at
\]

Consider the sentence “the agent detects the wumpus at [1,2]”.

(a) Show two different parse trees of this sentence based on the above grammar, and give the interpretation (in English) of each parse tree.

(b) Now consider the same probabilistic grammar below (identical to the grammar in (a)) but with probability values as above. Calculate the probability of each of the two parses.

\[
S \Rightarrow NP \ VP \ [1.0] \\
NP \Rightarrow Noun \ [.1] \ | \ Article \ Noun \ [.4] \ | \ NP \ PP \ [.3] \ | \ Noun \ Noun \ [.2] \\
VP \Rightarrow Verb \ [.5] \ | \ VP \ NP \ [.3] \ | \ VP \ PP \ [.2] \\
PP \Rightarrow Preposition \ NP \ [1.0] \\
Article \Rightarrow the \ [1.0] \\
Noun \Rightarrow agent \ [.4] \ | \ wumpus \ [.2] \ | \ [1,2] \ [.4] \\
Verb \Rightarrow detects \ [.1] \\
Preposition \Rightarrow at \ [1.0]
\]

(c) If the probability of the rule

\[
NP \Rightarrow Noun \ [.1] \ | \ Article \ Noun \ [.4] \ | \ NP \ PP \ [.3] \ | \ Noun \ Noun \ [.2]
\]

was changed to:

\[
NP \Rightarrow Noun \ [.1] \ | \ Article \ Noun \ [.5] \ | \ NP \ PP \ [.3] \ | \ Noun \ Noun \ [.1]
\]

would the parsing results change? Why or why not?

2. (Modified from Question 22.9 of the textbook) Consider the sentence “someone walked slowly to the supermarket” and the following lexicon:

\[
Pronoun \Rightarrow someone \\
Verb \Rightarrow walked \\
Adv \Rightarrow slowly \\
Prep \Rightarrow to
\]
Article ⇒ the
Noun ⇒ supermarket

Which of the following three grammars, combined with the lexicon, generates the given sentence? Show the corresponding parse tree(s).

Grammar A:
S ⇒ NP VP
NP ⇒ Pronoun
NP ⇒ Article Noun
VP ⇒ VP PP
VP ⇒ VP Adv Adv
VP ⇒ Verb
PP ⇒ Prep NP
NP ⇒ Noun

Grammar B:
S ⇒ NP VP
NP ⇒ Pronoun
NP ⇒ Noun
NP ⇒ Article NP
VP ⇒ Verb Vmod
Vmod ⇒ Adv Vmod
Vmod ⇒ Adv
Adv ⇒ PP
PP ⇒ Prep NP

Grammar C:
S ⇒ NP VP
NP ⇒ Pronoun
NP ⇒ Article NP
VP ⇒ Verb Adv
Adv ⇒ Adv Adv
Adv ⇒ PP
PP ⇒ Prep NP
NP ⇒ Noun

3. Consider the following context-free grammar that generates sequences of letters:
S ⇒ a X c
S ⇒ b X c
S ⇒ b X e
S ⇒ c X e
X ⇒ f X
X ⇒ g

(a) Give a trace of the top-down parse on the input bfge
(b) Give a trace of the bottom-up parse on the same input $bfge$

(c) Which approach is better in this case?

4. Give context-free grammars for

(a) The set of all strings of the form: $n$ occurrences of $a$s, followed by any number of $b$s, followed by any number of $c$s, followed by $n$ occurrences of $d$

(b) The set of palindromes (strings that read the same forward as backward) over alphabet \{a, b\}

5. Show the CYK chart and most likely parse of the sentence “the girl saw the man with the telescope”, given the following grammar and lexicon.

$$S \Rightarrow \text{NP VP} \ [1.0]$$
$$\text{NP} \Rightarrow \text{NP PP} \ [0.3] \ | \ \text{Article Noun} \ [0.7]$$

$$\text{VP} \Rightarrow \text{VP PP} \ [0.4] \ | \ \text{Verb NP} \ [0.6]$$
$$\text{PP} \Rightarrow \text{Prep NP} \ [1.0]$$

$$\text{Article} \Rightarrow \text{the} \ [1.0]$$
$$\text{Noun} \Rightarrow \text{girl} \ [0.4] \ | \ \text{man} \ [0.2] \ | \ \text{telescope} \ [0.4]$$
$$\text{Verb} \Rightarrow \text{saw} \ [1.0]$$
$$\text{Preposition} \Rightarrow \text{with} \ [1.0]$$