

## Solution to Written Assignment #2

1. (24 pts)

(a) Suppose a shallow parser (chunker) is applied to the sentences below. Label all prepositional phrase (PP) chunks and base noun phrase (NP) chunks that should be produced for each sentence. Be sure to label an NP even if it is nested in a PP. For examples '*He stays in Salt Lake City*' should be '[NP: He] stays [PP: in [NP: Salt Lake City]]'.

i. John gave Mary a book as a gift.

[NP: John] gave [NP: Mary] [NP: a book] [PP: as [NP: a gift]]

ii. A person in the park threw a bone to his dog.

[NP: A person] [PP: in [NP: the park]] threw [NP: a bone] [PP: to [NP: his dog]]

iii. In July Bob will sell his food truck.

[PP: In [NP: July]] [NP: Bob] will sell [NP: his food truck]

iv. The mouse the cat caught died.

[NP: The mouse] [NP: the cat] caught died.

v. The storm destroyed a large number of properties in the city.

[NP: The storm] destroyed [NP: a large number] [PP: of [NP: properties]] [PP: in [NP: the city]]

(b) Label each sentence below with BIO tags corresponding to the NP chunks that you identified in part (a).

i. John gave Mary a book as a gift.

John/B gave/O Mary/B a/B book/I as/O a/B gift/I.

ii. A person in the park threw a bone to his dog.

A/B person/I in/O the/B park/I threw/O a/B bone/I to/O his/B dog/I

iii. In July Bob will sell his food truck.

In/O July/B Bob/B will/O sell/O his/B food/I truck/I

iv. The mouse the cat caught died.

The/B mouse/I the/B cat/I caught/O died/O

- v. The storm destroyed a large number of properties in the city.  
The/B storm/I destroyed/O a/B large/I number/I of/O properties/B in/O the/B  
city/I

2. (24 pts) In this question, you are going to use the CKY algorithm to parse a sentence. (Use the ordinary CKY algorithm, not probabilistic CKY.)

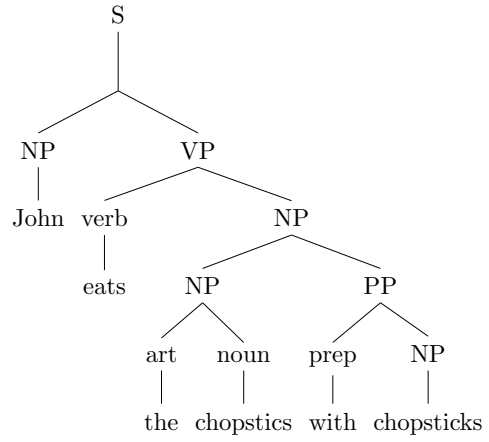
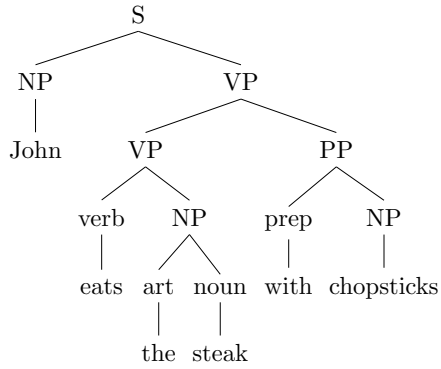
- (a) List all table entries produced by the CKY algorithm for the sentence ‘*John eats the steak with chopsticks*’ using the grammar below. Each entry  $\text{table}[i,j]$  refers to the cell for row  $i$  and column  $j$  in the table. For example,  $\text{table}[1,4]$  should contain constituents that span words 1 through 4.

$S \rightarrow NP VP$   
 $NP \rightarrow NP PP$   
 $NP \rightarrow \text{art noun}$   
 $PP \rightarrow \text{prep NP}$   
 $VP \rightarrow VP PP$   
 $VP \rightarrow \text{verb NP}$   
  
 $NP \rightarrow \text{John}$   
 $NP \rightarrow \text{chopsticks}$   
 $NP \rightarrow \text{steak}$   
 $\text{noun} \rightarrow \text{John}$   
 $\text{noun} \rightarrow \text{chopsticks}$   
 $\text{noun} \rightarrow \text{steak}$   
 $\text{verb} \rightarrow \text{eats}$   
 $\text{prep} \rightarrow \text{with}$   
 $\text{art} \rightarrow \text{the}$

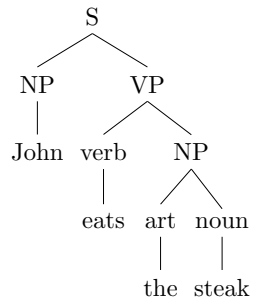
$\text{table}[1,1]: \{NP, \text{noun}\}$   
 $\text{table}[1,2]: -$   
 $\text{table}[1,3]: -$   
 $\text{table}[1,4]: \{S\}$   
 $\text{table}[1,5]: -$   
 $\text{table}[1,6]: \{S, S\}$   
 $\text{table}[2,2]: \{\text{verb}\}$   
 $\text{table}[2,3]: -$   
 $\text{table}[2,4]: \{VP\}$   
 $\text{table}[2,5]: -$   
 $\text{table}[2,6]: \{VP, VP\}$   
 $\text{table}[3,3]: \{\text{art}\}$   
 $\text{table}[3,4]: \{NP\}$   
 $\text{table}[3,5]: -$   
 $\text{table}[3,6]: \{NP\}$   
 $\text{table}[4,4]: \{NP, \text{noun}\}$   
 $\text{table}[4,5]: -$   
 $\text{table}[4,6]: \{NP\}$   
 $\text{table}[5,5]: \{\text{prep}\}$   
 $\text{table}[5,6]: \{PP\}$   
 $\text{table}[6,6]: \{NP, \text{noun}\}$

- (b) Draw the parse tree for every S constituent produced in the table for part (a). For each one, please indicate which cell the S constituent appears in.

S in table[1,6]:



S in table[1,4]:



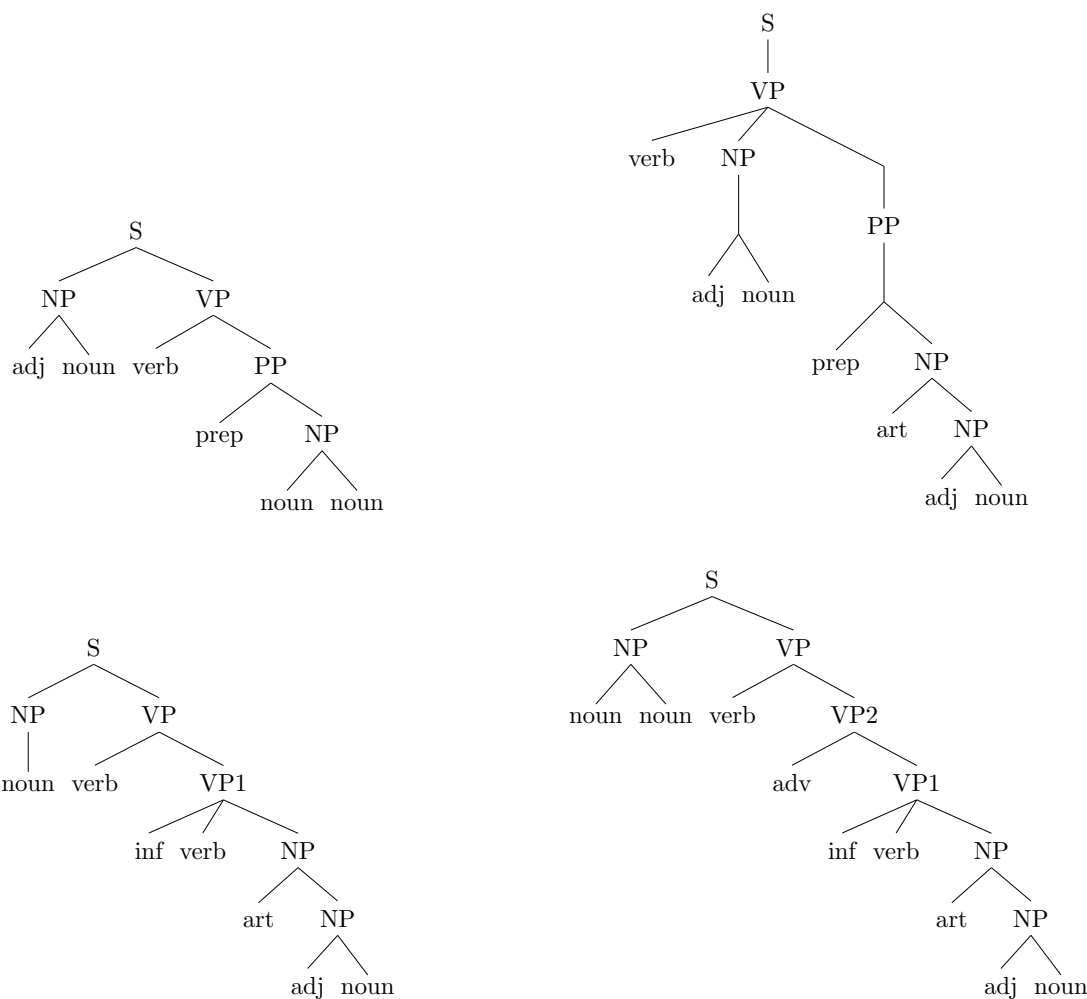
3. (18 Pts) Given the grammar G2 and the sentence '*the dog park is closed*', fill in a chart using the Earley chart parsing algorithm. Each chart entry should be a constituent or a rule, with a start and end position indicating the range of words that have been matched by the constituent or rule. For example, 'NP[1-4]' should be used for an NP that matches words in positions 1-3 (thus ends at position 4). Similarly, 'S → NP \* VP [1,3]' means that the NP has matched the words in positions 1-2 and the rule is anticipating a VP starting in position 3. Assume that the first word in the sentence is in position 1.

<p><b>G2</b></p> <p>S → NP VP</p> <p>S → VP NP</p> <p>VP → verb VP</p> <p>VP → verb</p> <p>NP → art NP</p> <p>NP → noun noun</p> <p>noun → dog   park</p> <p>verb → closed   park   is</p> <p>art → the</p>
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Below, we have created the part-of-speech constituents that belong in the chart to get you started. Please fill in the remaining entries!

Constituent or Rule	Start-End
art("the")	[1-2]
noun("dog")	[2-3]
noun("park")	[3-4]
verb("park")	[3-4]
verb("is")	[4-5]
verb("closed")	[5-6]
$S \rightarrow^* NP VP$	[1,1]
$S \rightarrow^* VP NP$	[1,1]
$NP \rightarrow^* art NP$	[1,1]
$NP \rightarrow^* noun noun$	[1,1]
$VP \rightarrow^* verb VP$	[1,1]
$VP \rightarrow^* verb$	[1,1]
$NP \rightarrow art^* NP$	[1,2]
$NP \rightarrow^* art NP$	[2,2]
$NP \rightarrow^* noun noun$	[2,2]
$NP \rightarrow noun^* noun$	[2,3]
$NP \rightarrow noun noun^*$	[2,4]
$NP$	[2,4]
$NP \rightarrow art NP^*$	[1,4]
$NP$	[1,4]
$S \rightarrow NP^* VP$	[1,4]
$VP \rightarrow^* verb VP$	[4,4]
$VP \rightarrow^* verb$	[4,4]
$VP \rightarrow verb^* VP$	[4,5]
$VP \rightarrow verb^*$	[4,5]
$VP$	[4,5]
$S \rightarrow NP VP^*$	[1,5]
$S$	[1,5]
$VP \rightarrow^* verb VP$	[5,5]
$VP \rightarrow^* verb$	[5,5]
$VP \rightarrow verb^* VP$	[5,6]
$VP \rightarrow verb^*$	[5,6]
$VP$	[5,6]
$VP \rightarrow verb VP^*$	[4,6]
$VP$	[4,6]
$S \rightarrow NP VP^*$	[1,6]
$S$	[1,6]

4. (14 pts) Consider the four parse trees below:



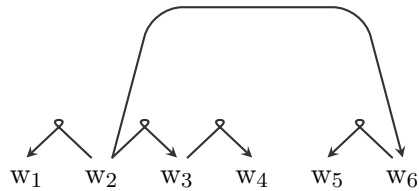
Consider these four parse trees to be a (tiny!) Treebank, and construct a probabilistic context-free grammar (PCFG) from this Treebank. List all distinct context-free grammar rules that are depicted in the trees above and compute their probabilities.

Rules	Probability
$S \rightarrow NP VP$	$\frac{3}{4}$
$S \rightarrow VP$	$\frac{1}{4}$
$NP \rightarrow adj noun$	$\frac{5}{11}$
$NP \rightarrow noun noun$	$\frac{2}{11}$
$NP \rightarrow art NP$	$\frac{3}{11}$
$NP \rightarrow noun$	$\frac{1}{11}$
$VP \rightarrow verb PP$	$\frac{1}{4}$
$VP \rightarrow verb NP PP$	$\frac{1}{4}$
$VP \rightarrow verb VP1$	$\frac{1}{4}$
$VP \rightarrow verb VP2$	$\frac{1}{4}$
$VP1 \rightarrow inf verb NP$	1
$VP2 \rightarrow adv VP1$	1
$PP \rightarrow prep NP$	1

5. (20 pts) For each sentence below, draw the dependency relations that would be produced by applying the given sequence of shift-reduce operations.  $w_i$  means the  $i^{th}$  word in the sentence. (The dependency relations will be *unlabeled* directed edges.)

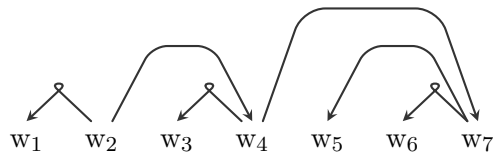
(a) SENTENCE:  $w_1 w_2 w_3 w_4 w_5 w_6$

OPERATIONS: Shift, Shift, LeftArc, Shift, Shift, RightArc, RightArc, Shift, Shift, LeftArc, RightArc



(b) SENTENCE:  $w_1 w_2 w_3 w_4 w_5 w_6 w_7$

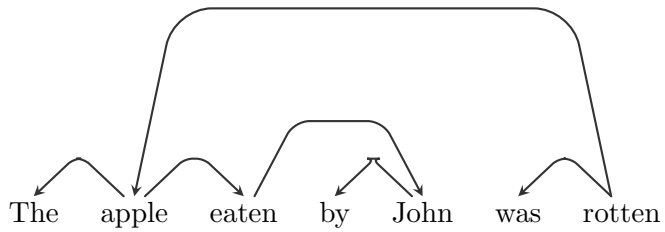
OPERATIONS: Shift, Shift, LeftArc, Shift, Shift, LeftArc, Shift, Shift, Shift, LeftArc, LeftArc, RightArc, RightArc



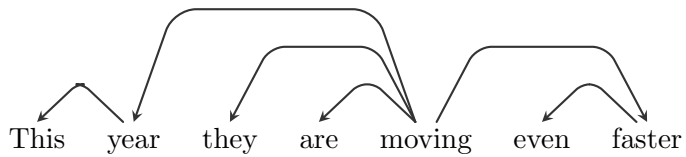


**Question #6 is for CS-6340 students ONLY!**

6. (13 pts) For each dependency graph below, determine the sequence of shift-reduce operations that should be predicted by the oracle in order to produce the graph.



Shift, Shift, LeftArc, Shift, Shift, Shift, LeftArc, RightArc, RightArc, Shift, Shift, LeftArc, LeftArc



Shift, Shift, LeftArc, Shift, Shift, Shift, LeftArc, LeftArc, LeftArc, Shift, Shift, LeftArc, RightArc