

Ques 2(a) He gave her a pen

Stack	Buffer	Arcs.	operations
[ ] <sub>s</sub>	[He gave, her, a, pen, .] <sub>B</sub>		
[He] <sub>s</sub>	[ gave, her, a, pen, .] <sub>B</sub>	He $\xleftarrow{SBS}$ gave	SH.
[ ] <sub>s</sub>	[gave, her, a, pen, .] <sub>B</sub>		LA
[gave] <sub>s</sub>	[her, a, pen, .] <sub>B</sub>	gave $\xrightarrow{IOBS}$ her	SH
[gave, her] <sub>s</sub>	[a, pen, .] <sub>B</sub>		RA
[gave, her, a] <sub>s</sub>	[ pen, .] <sub>B</sub>	a $\xleftarrow{det}$ pen	SH
[gave, her]	[ pen, .] <sub>B</sub>		LA
[ gave] <sub>s</sub>	[ pen, .] <sub>B</sub>		RE
[gave, pen] <sub>s</sub>	[.] <sub>B</sub>	gave $\xrightarrow{IOBS}$ pen	RA
[gave] <sub>s</sub>	[.] <sub>B</sub>	gave pen	RE
[gave, .] <sub>s</sub>	[.] <sub>B</sub> $\rightarrow$ empty	gave pen.	RA

Qb) See the slides

day	count	2 gram	current	1 gram	count
3 gram					
A beautiful day	5	beautiful day	7	day	20
A beautiful night	0	beautiful night	0	night	5

$$P_{bd}(\text{day} | \text{a beautiful}) = \frac{5}{25} - \frac{1}{8} = 1 - \frac{1}{8} = \frac{7}{8}$$

$$P_{nd}(\text{night} | \text{a beautiful}) = 1 - P(\text{day} | \text{a beautiful})$$

$$\therefore P(\text{night} | \text{beautiful}) = d_2 P(\text{night})$$

$$P(\text{night}) = \frac{5}{25} - \frac{1}{8} = \frac{3}{40} = 0.075$$

$$P(\text{night} | \text{beautiful}) + P(\text{day} | \text{beautiful}) = 1$$

$$\frac{3d_2}{40} + \left(1 - \frac{1}{8}\right) = 1$$

$$\frac{3d_2}{40} = \frac{1}{8}$$

$$d_2 = \frac{5}{3} = \cancel{\frac{5}{3}}$$

$$d_2 P(\text{night}) \quad P(\text{night} | \text{beautiful}) = d_2 P(\text{night})$$

$$= \frac{5}{3} \left[ \frac{5}{25} - \frac{1}{8} \right]$$

$$= \frac{5}{3} \times \left[ \frac{3}{40} \right] = \frac{1}{8}$$

PTO

Ans 3

3 gram	
A beautiful	
dey	
r	

Ans 3 Contd

$$P(\text{dey} \mid \text{a beautiful}) + P(\text{night} \mid \text{a beautiful}) = 1$$

$$\frac{7}{8} + \frac{d_1}{8} = 1$$

$$7 + d_1 = 8$$

$$d_1 = 1$$

$$P_{\text{nd}}(\text{night} \mid \text{a beautiful}) = d_1 P(\text{night} \mid \text{beautiful}) = \frac{1}{8}$$

$$P(\text{dey} \mid \text{a beautiful}) = \frac{7}{8}$$

Next word should be "dey"

Aus3

- (i) A stone smelled the color blue :- leniently & syntactically correct but semantically incorrect
- (ii) It kinds of a :- leniently incorrect

$$\text{Determiner: } 0.05 \times 0.05 \\ = 0.0025$$

$$\text{Verb: } 0.05 \times 0.05 \\ = 0.0025$$

$$\text{Noun: } 0.9 \times 0.9 \\ = 0.81$$

Bob

ate

the

$$\text{MAX} \left\{ \begin{array}{l} 0.0025 \times 0.1 + 0.9 \text{ (Det)} \\ 0.0025 \times 0.1 + 0.9 \text{ (Verb)} \\ 0.81 \times 0.8 + 0.9 \text{ (Noun)} \\ \hline = 0.5832 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.0025 \times 0.8 + 0.05 \text{ (Det)} \\ 0.0025 \times 0.1 + 0.05 \text{ (Verb)} \\ 0.81 \times 0.1 + 0.05 \text{ (Noun)} \\ \hline = 0.00405 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.0025 \times 0.1 + 0.05 \text{ (Det)} \\ 0.0025 \times 0.8 + 0.05 \text{ (Verb)} \\ 0.81 \times 0.1 + 0.05 \text{ (Noun)} \\ \hline = 0.00405 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.5832 \times 0.1 + 0.05 \text{ (Det)} \\ 0.00405 \times 0.1 + 0.05 \text{ (Verb)} \\ 0.00405 \times 0.8 + 0.05 \text{ (Noun)} \\ \hline = 0.00405 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.5832 \times 0.8 + 0.05 \text{ (Det)} \\ 0.00405 \times 0.1 + 0.05 \text{ (Verb)} \\ 0.00405 \times 0.1 + 0.05 \text{ (Noun)} \\ \hline = 0.00405 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.5832 \times 0.1 + 0.05 \text{ (Det)} \\ 0.00405 \times 0.8 + 0.05 \text{ (Verb)} \\ 0.00405 \times 0.1 + 0.05 \text{ (Noun)} \\ \hline = 0.00405 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.0025 \times 0.1 + 0.05 \text{ (Det)} \\ 0.41994 \times 0.1 + 0.05 \text{ (Verb)} \\ 0.002916 \times 0.8 + 0.05 \text{ (Noun)} \\ \hline = 0.002916 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.002916 \times 0.8 + 0.05 \text{ (Det)} \\ 0.41994 \times 0.1 + 0.05 \text{ (Verb)} \\ 0.002916 \times 0.1 + 0.05 \text{ (Noun)} \\ \hline = 0.002916 \end{array} \right.$$

$$\text{MAX} \left\{ \begin{array}{l} 0.002916 \times 0.1 + 0.05 \text{ (Det)} \\ 0.41994 \times 0.8 + 0.05 \text{ (Verb)} \\ 0.002916 \times 0.1 + 0.05 \text{ (Noun)} \\ \hline = 0.002916 \end{array} \right.$$

fruit

Defn: The best sequence  
is Noun Det Verb Noun.

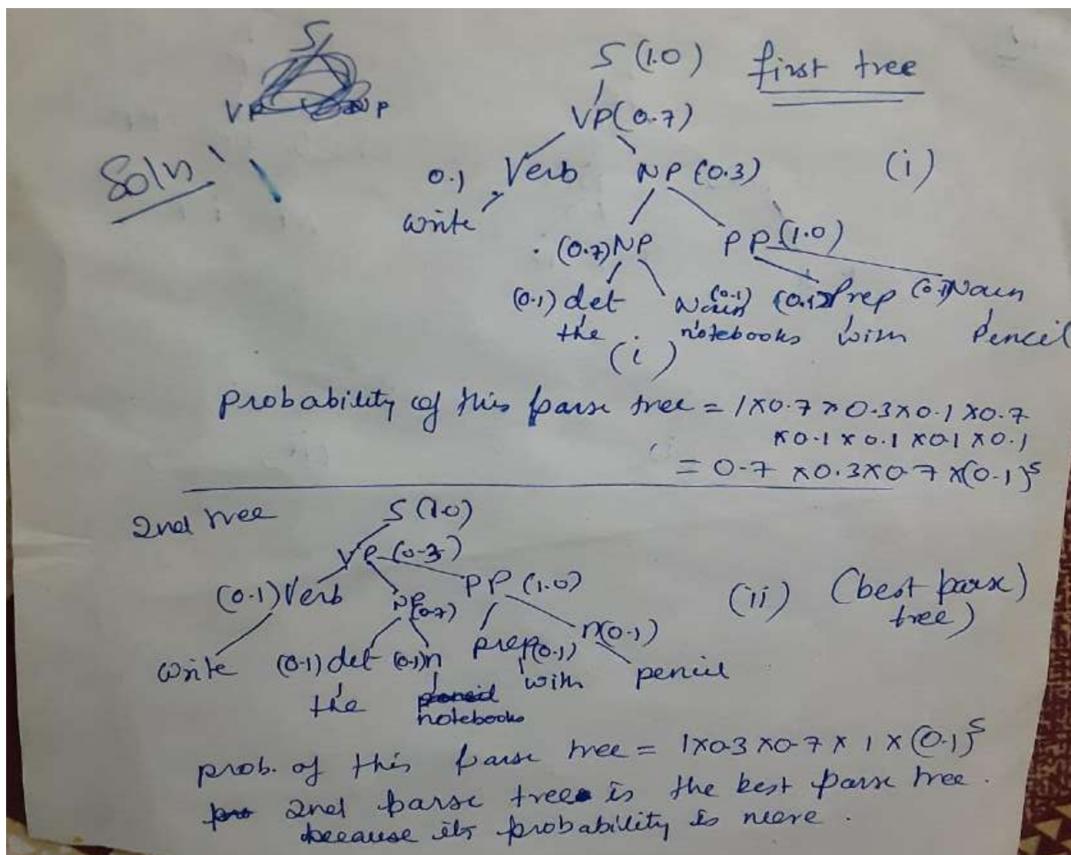
**Q.1 (5+1=6 marks)**

a) Draw the top-ranked parse tree for the sentence below by applying the PCFG given in below table. Does the results are good? Provide your comments.

Sentence: Write the notebooks with pencil.

Consider the following PCFG

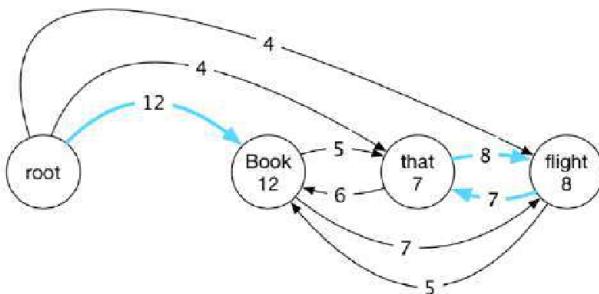
$S \rightarrow VP$	1.0
$VP \rightarrow Verb \ NP$	0.7
$VP \rightarrow Verb \ NP \ PP$	0.3
$NP \rightarrow NP \ PP$	0.3
$NP \rightarrow Det \ Noun$	0.7
$PP \rightarrow Prep \ Noun$	1.0
$Det \rightarrow the$	0.1
$Verb \rightarrow Write \mid Ask \mid Find \dots$	0.1
$Prep \rightarrow with \mid in \mid \dots$	0.1
$Noun \rightarrow notebooks \mid teacher \mid pencil \mid college \mid bike \mid summer \mid \dots$	0.1



b) Which of the three Noun Phrases (1. Pronoun, 2. Proper Noun, 3. Common Noun) to be the most difficult to handle computationally while performing top-down parsing. Explain why?

### Q2. (6+2=8 marks)

a). Does the following stage of a Edmond algorithm parsing has an MST? If not, continue the algorithm for one more step with an Explanation. Obtain MST.



Q2 Ans is No. Because there is a cycle b/w words that & flight. To remove the cycle & get an MS for each node Book, that, flight we select the edge having the max weight.

Outgoing arcs  
 $\max(\text{flight} \rightarrow \text{book}, \text{that} \rightarrow \text{book}) = \max(5, 6) = 6.$

Now we connect every pair of vertices

Now we select for each vertex max incoming arc

Final MST (Soln)

Final MST (Soln)

Max (root  $\rightarrow$  that  $\rightarrow$  flight, root  $\rightarrow$  flight  $\rightarrow$  that)  
 $= \max(4+8, 4+7) = 12$  (that  $\rightarrow$  flight)

Max (Book  $\rightarrow$  that  $\rightarrow$  flight, Book  $\rightarrow$  flight  $\rightarrow$  that)  
 $= \max(5+8, 7+7) = 14$  (flight  $\rightarrow$  that)

Max (Book  $\rightarrow$  book, that  $\rightarrow$  book)  
 $= \max(12, 14) = 14$  (book  $\rightarrow$  book)

**b) What are the basic differences between syntactic parsing and dependency parsing.**

**Ans: See from the slides**

**Q3 (6+2=8 marks)**

**a) Given, the following training corpus, Using a bigram language model with and without add-one smoothing, what is P(Delhi is beautiful)?**

<s> Delhi is the capital of India </s>

<s> Delhi is cold </s>

<s> Delhi has beautiful gardens </s>

**Solution:**

$$P(\text{Delhi is beautiful}) = P(\text{Delhi} | \text{<s>}) * P(\text{is} | \text{Delhi}) * P(\text{beautiful} | \text{is}) * P(\text{</s>} | \text{beautiful})$$

$$P(\text{wn} | \text{wn-1}) = C(\text{wn-1 wn}) / C(\text{wn-1})$$

**Without Smoothing**

$$P(\text{Delhi} | \text{<s>}) = 3/3 = 1$$

$$P(\text{is} | \text{Delhi}) = 2/3 = 0.676$$

$$P(\text{beautiful} | \text{is}) = 0/2 = 0$$

$$P(\text{</s>} | \text{beautiful}) = 0/1 = 0$$

Unique words = 10

**With Smoothing**

$$P(\text{Delhi} | \text{<s>}) = (3+1)/(3+10) = 0.31$$

$$P(\text{is} | \text{Delhi}) = (2+1)/(3+10) = 0.23$$

$$P(\text{beautiful} | \text{is}) = (0+1)/(2+10) = 0.08$$

$$P(\text{</s>} | \text{beautiful}) = (0+1)/(1+10) = 0.09$$

$$P(\text{Delhi is beautiful}) = 0.31 * 0.23 * 0.08 * 0.09 = 5.13 * 10^{-4}$$

**b) Suppose the sentence consists of random alphabets (A, a, B, b, ..., Z, z) and each of the 26 letters in upper and lower case occurs with equal probability. What is the perplexity of this sentence?**

$$PP(W) = P(w_1 w_2 \dots w_N)^{-1/N}$$

Since both upper and lower cases are considered 52 letters have equal probability.

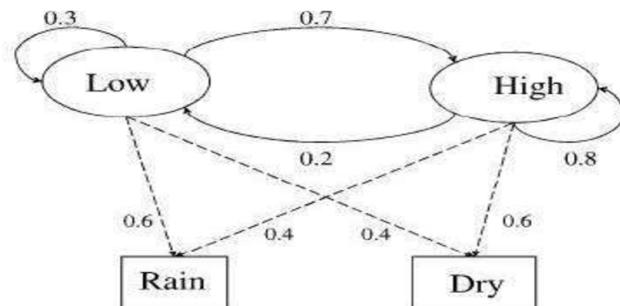
$$\text{Perplexity is } \left( \left( \frac{1}{52} \right)^{52} \right)^{-1/52}$$

$$= 52$$

**Q4. (3+5=8 marks)**

**The following diagram describes HMM model with two hidden states: Low and High**

and the observations are rainy and dry. Both the states are equally probable to be initial states



- a) Construct transition state matrix and emission matrix.
  - b) Let the observation sequence be given as Dry, Rain. Give the corresponding Hidden state sequence.

		Transition matrix		Emission matrix	
		Low	High	Dry	Dry
Low	Low	0.3	0.7	0.6	0.4
High	Low	0.2	0.8	0.4	0.6
		Observation sequence is Dry, Rain		Hidden state could be Low low, Low High, High low, High High	
<u>Low</u>	$0.5 \times 0.4$ $= 0.2$	$\min \{ \frac{0.2 \times 0.2 \times 0.6}{0.3 \times 0.2 \times 0.6} \}$ (L) <del>(M)</del>		Low	
<u>High</u>	$0.5 \times 0.6$ $= 0.2$	$\min \{ \frac{0.7 \times 0.2 \times 0.4}{0.8 \times 0.3 \times 0.4} \}$ (L) <del>(M)</del> Max		High	
Dry		Rain			
<u>Aus</u>	High	High			

**Ques:**

**7 Marks**

**Compute the BLEU score for the following example.[Hint :Use unigram,bigram,trigram and brevity penalty also]**

**Reference 1: the dog is on the grass**

**Reference 2: there is a dog on the grass**

**Candidate: the dog dog on the grass grass**

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**Ques:**

**[2+3=5 marks]**

**a) There are different types of questions in Modern systems. Which type is the following question:  
"How many variations of the COVID Vaccine are available?"**

**b) Find Domain, Intent and Define Slots for each of the following Sentences:**

- i) Find me a cheap South Indian restaurant in Delhi**
  - ii). Book an Appointment on Sunday 10:00 AM for Hair spa**
  - iii). What will be the weather tomorrow morning in New Delhi?**
-

2020

WEEK 10

Sln 3

APRIL

MONDAY  
DAY 104-262

13

Ref 1: the dog is on the grass

Ref 2: there is a dog on the grass

Candidate: the dog dog on the grass grass

Unigram

word	count	Ref 1	Ref 2	$\text{next}(\text{Ref1}, \text{Ref2})$	$\min(\text{count}, R)$
the	2	2	1	1	1
dog	2	1	1	1	1
on	1	1	1	1	1
grass	2	1	1	1	1
Total =	7				5 (total)

TUESDAY  
DAY 105-261

14

Unigram = 5/7

Bigram words	count	Ref 1	Ref 2	$\text{next}(\text{Ref1}, \text{Ref2})$	$\min(\text{count}, R)$
the dog	1	1	0	1	1
dog dog.	1	0	0	0	0
dog on	1	0	1	1	1
on the	1	1	1	1	1
the grass	1	1	0	0	0
grass grass	1	0	0	0	0
	6				4

$$\text{Bigram} = 4/6 = 2/3$$

M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

MAY  
2020

APRIL

15 WEDNESDAY

word	Trigrams ref1	ref2	R1 min(R1, R2)	R2 max(R1, R2)	sum(R1+R2)
The dog dog	0	0	0	0	0
dog dog on	0	0	1	1	1
dog on the	1	0	1	1	1
on the gun	1	0	0	1	1
the gun gun	1	0	0	1	1
Total = 5					2

Trigram = 2/5.

$$[C] = 7, \text{ 80}$$

16 THURSDAY

$$[Ref1] = 6$$

$$[Ref2] = 7$$

if students assume (Ref1) to be best answer then  $B.P = R1 \times P$

$$B.P = 1$$

$$\begin{aligned} \text{Please score} &= B.P \times P \\ &= 1 \times \left( \frac{2}{7} \times \frac{2}{3} \times \frac{1}{8} \right)^{1/3} \end{aligned}$$

2020

WEEK 16

APRIL

FRIDAY

17

Ans ④ factoid question

- (b) D → find a cheap restaurant south Indian in Delhi

Domain : Restaurant

Intent : to look for restaurant -

food type : South Indian

place : Delhi

cost : cheap

Book an appointment on Sunday for Hair Spa.

SATURDAY

18

Domain : Salon

Intent : Book an appointment -

Service : Hair Spa

Day : Sunday

Time : 10 a.m.

What will be weather tomorrow morning in New Delhi?

Domain : Weather forecasting

Intent : New weather

Day : Tomorrow

Place : Delhi

Time : Morning

MAY

2020

1. a) Give the correct sequence of arc eager parsing operations for the given sentence [2marks]



b) Provide a modified transition sequence where the parser mistakenly predicts the arc cat → slept, but gets the other dependencies right.

Solution:

a)

[Root, ]	[The lazy cat slept]	[]
[Root,The]	[ lazy cat slept]	[Shift]
[Root ,the ,Lazy]	[cat slept]	[Shift]
[Root ,the ,Lazy]	[cat slept]	[LA]
[Root the ]	[cat slept]	[ LA]
[Root,Cat]	[slept]	[SH]
[Root, ]	[ slept]	[LA]
[Root,Slept]	[]	[RA]
[Root]	[]	[RE]

SH,SH,LA,LA,SH,LA,RA

b)

[Root, ]	[The lazy cat slept]	[]
[Root,The]	[ lazy cat slept]	[Shift]
[Root ,the ,Lazy]	[cat slept]	[Shift]
[Root ,the ,Lazy]	[cat slept]	[LA]
[Root the ]	[cat slept]	[ LA]
[Root,Cat]	[slept]	[SH]
[Root, Cat ]	[]	[RA]
[Root,Cat ,Slept]	[]	[RE]
[Root,cat]	[]	[RE]
[Root]	[]	[ RE]

b) Given the grammar and lexicon below derive the parse tree using top down parsing method for the sentence [3 marks]

S :The guy ate pizza

**S->NP VP**

**VP->VNP**

**NP->Det N**

**N->pizza**

**N->guy ,Det ->the**

**V->ate**

Solution:

1The 2 guy 3 ate 4 the 5pizza 6

State	Backup State	Action
1.({S} 1)		
2.({(NP VP) 1})		
3.{(DT N VP) 1})		matches the
4.{(N VP) 2})		matches guy
5.{(VP)3})		
6.{(V NP ) 3})		matches ate
7.{( Det N) 4})		matches the
8.{(N )}5})		matches pizza
9.()		

2. Given the grammar and lexicon below show the final chart for the following sentence after applying the bottom up chart parser.[5 marks]

**S: Book the flight on airasia**

**S->VP**

**VP->V NP**

**NP->NP PP**

**NP->Det Noun**

**PP ->Prep Noun**