Problem 1.

1) (a) they are baking potatoes.

Possible POS tag sequences are

PRP → V → Adj → N — (1)

PRP → Aux → V → N — (2)

For 1st sequence

Prob (tags, words)

$= P(PRP \mid start) \cdot P(V \mid PRP) \cdot P(Adj \mid V) \cdot P(N \mid Adj) \cdot P(they \mid PRP) \cdot P(are \mid V) \cdot P(baking \mid Adj) \cdot P(potato \mid N)$

$= 0.1 \times 0.8 \times 0.3 \times 0.6 \times 1.0 \times 0.5 \times 1.0 \times 1.0$

$= 0.0072$

For 2nd sequence.

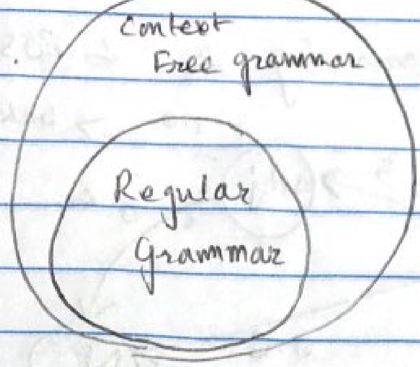
P(tags, words)

$= P(PRP \mid start) \cdot P(Aux \mid PRP) \cdot P(V \mid Aux) \cdot P(N \mid V) \cdot P(they \mid PRP) \cdot P(are \mid Aux) \cdot P(baking \mid V) \cdot P(potato \mid N)$

$= 0.1 \times 0.2 \times 1.0 \times 0.6 \times 1.0 \times 1.0 \times 0.5 \times 1.0$

$= \cancel{0.0012}\ 0.006$

1) c).

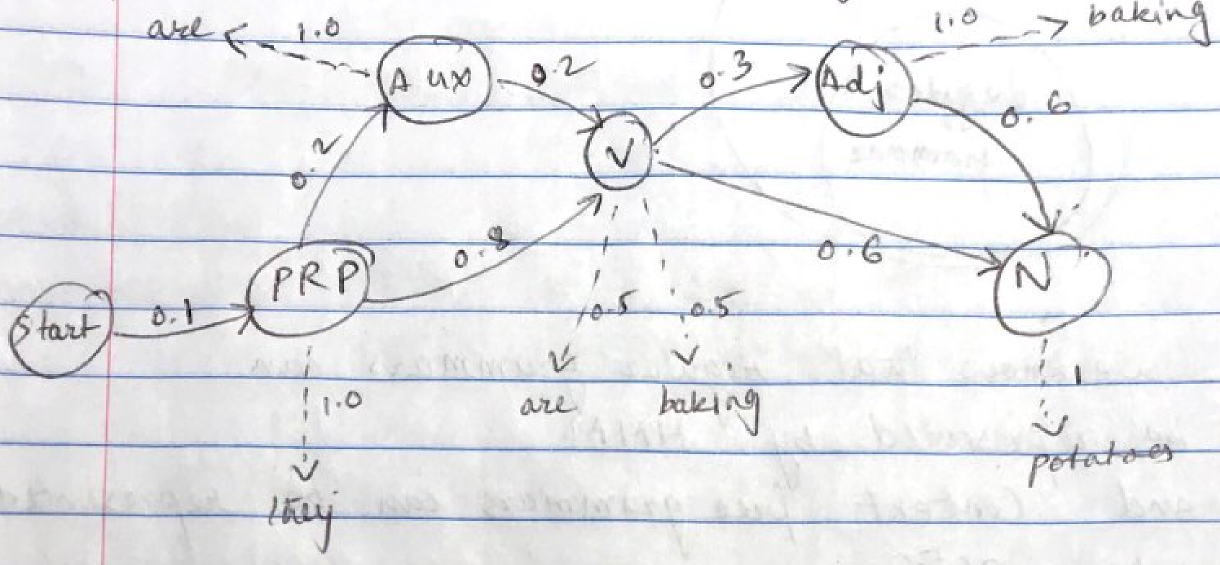


We know that regular grammars can be represented by HMM.
and Context free grammars can be represented by PCFG.

Since regular grammar is a subset of context free grammar,
we can say that ~~all~~ any HMM can be transformed into PCFG ~~but~~ of identical joint probability.
But any PCFG cannot be transformed into HMM.

~~1) b)~~.

1) b) HMM model representing the 2 POS sequences.



Problem 2.

chart [0].

~~S → * NP~~

s0 S → • NP VP [0,0] init.

s1 NP → • Adj NP [0,0] predict s0.

s2 NP → • PRP [0,0] predict s0

s3 NP → • N [0,0] predict s0.

s4 Adj → • baking [0,0] predict s1

s5 PRP → • they [0,0] predict s2

s6 N → • potatoes [0,0] predict s3.

chart [1].

s7 PRP → they • [0,1] scan s5

s8 NP → PRP • [0,1] complete s2 with s7.

s9 S → NP • VP [0,1], complete s0 with s8

s10 VP → • V NP [1,1] predict s9.

s11 VP → • Aux V NP [1,1] predict s9

s12 V → • baking. [1,1] predict s10

s13 V → • are [1,1] predict s10

s14 Aux → • are [1,1] predict s11

chart [2]

s15 V -> are • [1,2] scan s13

s16 Aux -> are • [1,2] scan s14

s17 VP -> V • NP [1,2] complete s10 with s15

s18 VP -> Aux • V NP [1,2] complete s11 with s16.

s19 NP -> • Adj NP [2,2] predict s17

s20 NP -> • PRP [2,2] predict s17.

s21 NP -> • N [2,2] predict s17.

s22 V -> • baking [2,2] predict s18.

s23 V -> • are [2,2] predict s18

s24 Adj -> • baking [2,2] predict s19

s25 PRP -> • They [2,2] predict s20.

s26 N -> • potatoes [2,2] predict s21.

chart [3].

s27 V -> barking • [2,3] scan s22

s28 Adj -> barking • [2,3] scan s24.

s29. NP -> Adj • NP [2,3] complete s19 with s28.

s30. VP -> Aux V • NP [1,3] complete s18 with s27.

s31 NP -> • Adj NP [3,3] predict s29 s30

s32 NP -> • PRP [3,3] predict s29 s30

s33 NP -> • N [3,3] predict s29 s30.

s34 Adj -> • baking [3,3] predict s31

s35 PRP -> • They [3,3] predict s32

s36 N -> • potatoes [3,3) predict s33

Chart [4]

S_{37} N → potatoes • [3,4] scan S_{36}

S_{38} NP → N • [3,4] complete S_{33} with S_{37}.

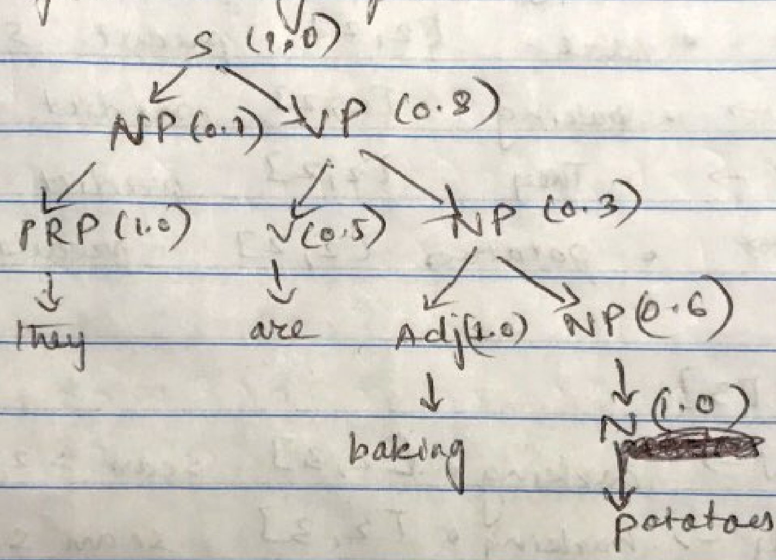
S_{39} VP → Aux V NP • [1,4] complete S_{30} with S_{38}

S_{40} NP → Adj NP • [2,4] complete S_{29} with S_{38}

S_{41} VP → V NP • [1,4] " S_{17} with S_{40}

S_{42} S → NP VP • [0,4] " S_9 with S_{38}, S_{40}.

2) (b) Tree 1 from earley parser:

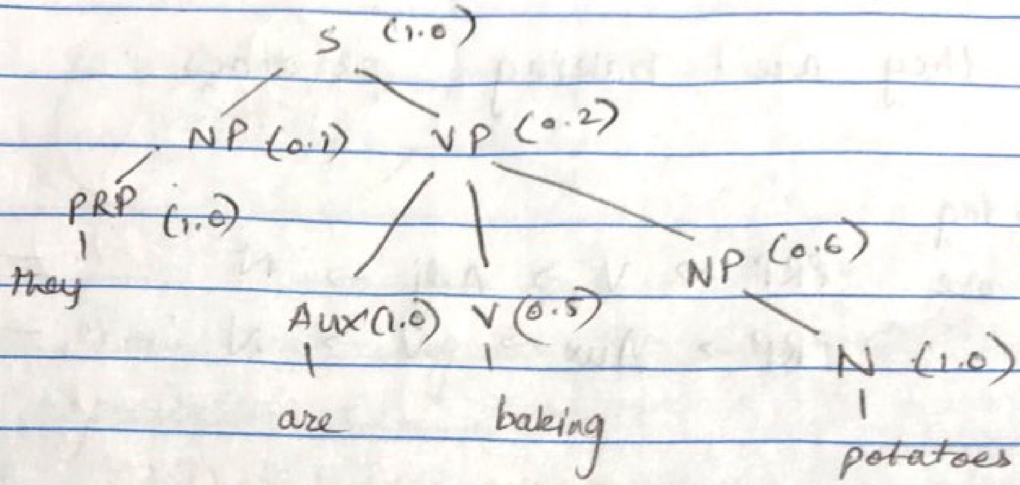


Probability (Tree 1)

$= 1.0 \times 0.1 \times 1.0 \times 0.8 \times 0.5 \times 0.3 \times 1.0 \times 0.6 \times 1.0$.

$= 0.0072$.

Tree 2 from Earley parser.



$$\text{Probability (Tree 2)} = 1.0 \times 0.1 \times 1.0 \times 0.2 \times 1.0 \times 0.5 \times 0.6 \times 1.0$$

$$= 0.006$$

Problem - 3

(a)

NP -> PRP (this violates CNF).

And, PRP -> they

=> NP -> they

NP -> N (violates CNF)

And, N -> potatoes.

=> NP -> potatoes

VP -> Aux V NP (violates CNF)

Let C -> V NP

=> VP -> Aux C

Newset of grammar :-

S -> NP VP.

NP -> Adj NP

NP -> They

NP -> potatoes.

VP -> V NP.

VP -> Aux C.

C -> V NP.

~~PRP -> They~~

~~N -> potatoes~~.

Adj -> baking.

V -> baking

V -> are

Aux -> are.

3) b)

	0 they 1	are 2	baking 3	potatoes 4
0	NP	—	—	S
1		V, Aux	—	VP, C
2			V, Adj	VP, NP, C
3				NP

S → NP VP

where VP such that

~~VP → V NP~~

VP → Aux C

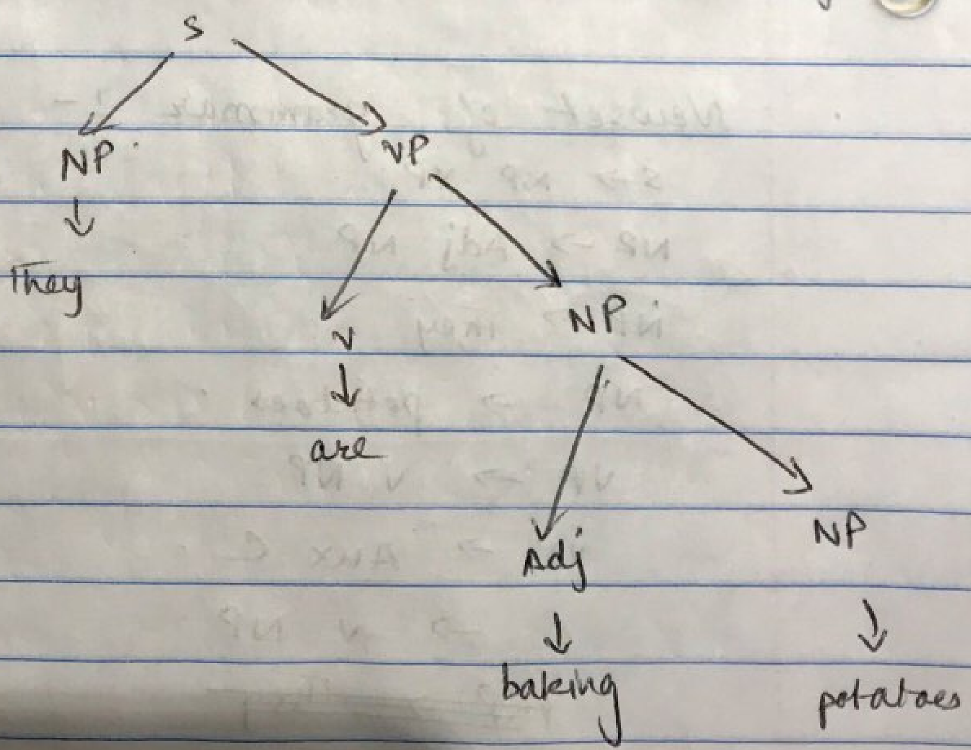
Here C → V NP

was not taken

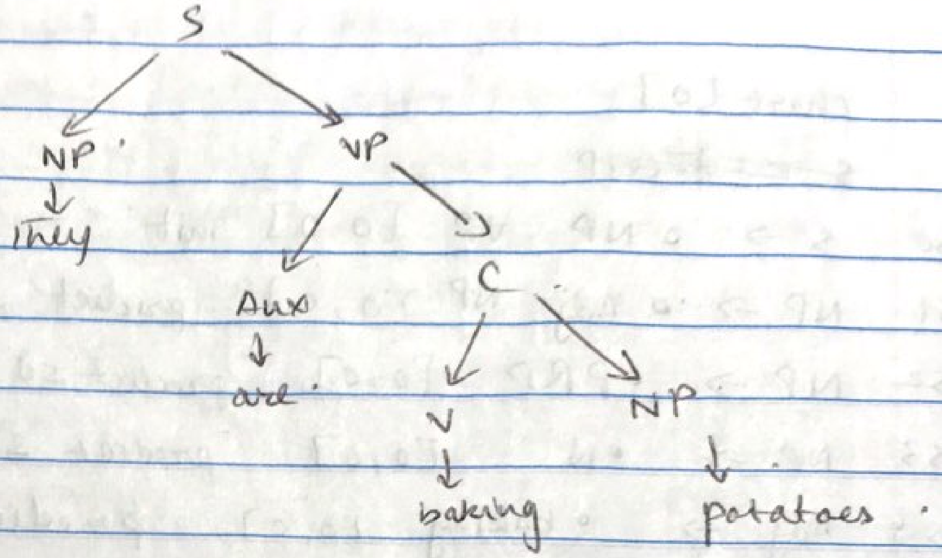
again due to

redundancy

Tree 1.



Tree 2.



initial state.

4) σ [root]   β: [he, sent, her, a, funny, meme, today]

Next transition: shift.

σ: $\boxed{\begin{array}{c} \text{he} \\ \text{root} \end{array}}$ β: [sent, her, a, funny, meme today].

Next transition :- Left arc

σ: [root]   β: [sent, her, a funny, meme, today]

nsubj

he sent.

Next transition :- Shift.

σ: $\boxed{\begin{array}{c} \text{sent} \\ \text{root} \end{array}}$ β: [her, a, funny, meme, today].

nsubj

he sent

Next transition: Right arc.

σ: [root]   β: [sent, a, funny, meme, today)

nsubj   iobj

he sent her

Next transition: Shift.

sent
root

σ:

B: [a, funny, meme, today].

nsubj iobj

he sent her

Next transition: shift

a
sent
root

σ:

B: [funny meme, today]

~~Next~~.

nsubj iobj

he sent her

Next transition: shift

funny
a
sent
root

σ:

B: [meme, today].

nsubj iobj

he sent her.

Next transition: Left-arc.

a
sent
root

σ:

B: [meme, today].

nsubj iobj

he sent her

amod.

funny meme.

Next transition: Left-arc

σ : $\boxed{\begin{array}{c} sent \\ root \end{array}}$ β: [meme, today] .

det   amod
nsubj   iobj
he sent her a funny meme.

Next transition :- Right-arc

σ : $\boxed{root}$ β: [sent, today]

det   dobj
nsubj   iobj   amod
he sent her a funny meme.

Next transition :- Shift .

σ : $\boxed{\begin{array}{c} sent \\ root \end{array}}$ β: [today] .

dobj
nsubj   iobj   det   amod
he sent her a funny meme.

Next transition :- Right Arc .

σ : $\boxed{root}$ β: [sent] .

advmod .
dobj
nsubj   iobj   det   amod
he sent her a funny meme. today .

Next transition :- Right Arc .

σ: $\boxed{}$ B: [root] .