Stanford University
Natural Language Processing

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Parsing

Question 1

Convert the following grammar to Chomsky Normal Form (as described in the lecture video):

X → Y Z W
X → Y Z

W → Z
W → *e*

Z → X W Z

- ---
  X → Y @X_Y
  X → Y Z
  @X_Y → Z W

  W → X @W_X
  W → X Z
  W → *e*/> W → Z
  @W_X → W Z

  Z → X @Z_X
  Z → X Z
  @Z_X → W Z

- ---
  X → @X_W W
  X → Y Z
  @X_W → Y Z

  W → @W_Z Z
  W → X Z
  @W_Z → X W

  Z → @Z_Z Z
  Z → X Z
  @Z_Z → X W

- ---
  X → Y @X_Y
  @X_Y → Z W
  X → Y Z

  W → Z
  W → *e*

  Z → X @Z_X
  @Z_X → W Z

- ---
  X → Y @X_Y
  X → Y Z
  @X_Y → Z W

  W → X @W_X
- W → X Z
  @W_X → W Z

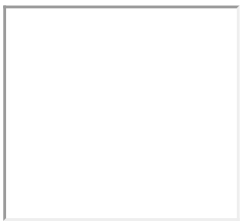
  Z → X @Z_X
  Z → X Z
  @Z_X → W Z

Question 2

Given the following grammar and transition probabilities:

S → NP VP	0.9
S → VP	0.1
VP → V NP	0.5
VP → V	0.1
VP → V @VP_V	0.3
VP → V PP	0.1
@VP_V → NP NP	1.0
NP → NP NP	0.1
NP → NP PP	0.2
NP → N	0.7
PP → P NP	1.0

And given the following part of the CKY matrix:



Which of the following constituents (and with what *maximum* probability) will be in the next cell?

- @VP_V: 0.084
- S: 0.05
- S: 0.0072
- NP: 0.42

Question 3

Given the following true and guessed parses, what is the LP/LR F1 (excluding any contribution from `ROOT`)?

```
Guess:
(ROOT
  (S
    (PP (IN In)
      (NP (NN addition)))
    (, ,)
    (NP
      (NP (DT the) (NN use))
      (PP (IN of)
        (NP (JJ IFN-U937) (NNS cells))))
    (VP (VBD reduced)
      (NP
        (NP (JJ interassay) (NN variation))
        (CC and)
        (NP (NN simplified) (NN assay) (NN performance))))
    (. .)))

Gold:
(ROOT
  (S
    (PP (IN In)
      (NP (NN addition)))
    (, ,)
    (NP
      (NP (DT the) (NN use))
      (PP (IN of)
        (NP (NN IFN-U937) (NNS cells))))
    (VP
      (VP (VBD reduced)
        (NP (JJ interassay) (NN variation)))
      (CC and)
      (VP (VBD simplified)
        (NP (NN assay) (NN performance))))
    (. .)))
```

- 0.7826
- 0.8182
- 0.7841
- 0.8302

Question 4

Lexicalize the following parse tree (annotate each non-terminal with the head of the phrase over which it is a constituent):

```
(S
  (NP (PRP$ her) (NN husband))
  (VP (VBD cleared)
    (NP
      (NP (DT a) (NN visit))
      (PP
        (IN by)
        (NP (PRP$ her) (NN mother))))))
(. .)
```

```
(S-cleared
  (NP-her (PRP$ her) (NN husband))
  (VP-cleared (VBD cleared)
    (NP-visit
      (NP-visit (DT a) (NN visit))
      (PP-by
        (IN by)
        (NP-her (PRP$ her) (NN mother))))))
(. .)
```

```
(S-cleared
  (NP-husband (PRP$ her) (NN husband))
  (VP-cleared (VBD cleared)
    (NP-mother
      (NP-visit (DT a) (NN visit))
      (PP-by
        (IN by)
        (NP-mother (PRP$ her) (NN mother))))))
(. .)
```

```
(S-cleared
  (NP-husband (PRP$ her) (NN husband))
  (VP-cleared (VBD cleared)
    (NP-visit
      (NP-visit (DT a) (NN visit))
      (PP-by
        (IN by)
        (NP-mother (PRP$ her) (NN mother))))))
(. .)
```

```
(S-husband
  (NP-husband (PRP$ her) (NN husband))
  (VP-cleared (VBD cleared)
    (NP-visit
      (NP-visit (DT a) (NN visit))
      (PP-by
        (IN by)
        (NP-mother (PRP$ her) (NN mother))))))
(. .)
```

Question 5

Given the following parse trees,

```
( (S (S (NP (PRP It))
        (VP (VBZ 's)
            (NP (NN summertime))))
     (, ,)
     (CC so)
     (S (NP (PRP it))
        (VP (MD must)
            (VP (VB be)
                (NP (NP (NN time))
                    (PP (IN for)
                        (NP (NN CAMP)))))))
     (. !)))

( (NP (NP (CD Six) (NNS weeks))
      (PP (IN of)
          (NP (NP (NN learning) (CC and) (NN exploring))
              (, ,)
```

```
            (NP (NNS sports) (, ,) (NNS arts) (, ,) (CC and) (NN fellowship))))
    (. .)))
```

What is the MLE probability of the rule `NP^PP -> NN` if we were to perform parent annotation?

- $2/3$
- $1/3$
- $1/2$
- $3/11$

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