Natural Language Processing  
Homework and Programming Assignment 1

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1. Please write regular expressions for the following:
   1. All binary strings. Example binary strings, 1001, 1011, 1111, etc.  
        
      [01]+
   2. The email address contains only letters, and @, \. Symbols (both lower and upper cases). Example:- alice@gmail.com, bob@yahoo.com, etc.  
        
      \w+@\w+.\w+
   3. Valid integer numbers. Examples: 1, 12843, -89232, +1262, etc.  
        
      [+-]?\d+
   4. Valid phone number that contains ten (10) digits. Consider valid phone number formats are given below.
      1. xxx-xxx-xxxx
      2. (xxx) xxx-xxxx

(\(\d{3}\) |\d{3}-)\d{3}-\d{4}

1. Determine the number of tokens and vocabulary and types from the below text:  
   “The quick brown fox jumps over the lazy dog.”  
     
   Tokens: the, quick, brown, fox, jumps, over, the, lazy, dog (9 tokens)  
   Types: the, quick, brown, fox, jumps, over, lazy, dog (8 types)  
   Vocabulary: Set of all types: {the, quick, brown, fox, jumps, over, lazy, dog}  
   |Vocabulary| = 8
2. Write down all the steps of text normalization and give an example for each step.

* Case Folding: Remove all capitals from the input. Ex: This is MY sentence. -> this is my sentence.
* Term Equivalence: If two words mean the same but have different spelling/an “s” on the end, swap them all to the same base. BUT check if the word means something different first. Ex: seal, seals, SEAL -> seal, seal, SEAL (Keep SEAL because it is an acronym)
* Lemmatization: Reduce all types of words to their most basic form. Ex: This is my mother’s sandwich -> This be my mother sandwich
* Stemming: Separate words into their stems and affixes. (Most of the time just keeping the stems). Ex: In continuation of the theme, I will continue to produce sentences. -> In continu of the theme, I will continu to produc sentence.
* Sentence Segmentation: Determine where the beginning/end of a sentence is. (Periods are ambiguous). Ex: The words Dr., Mrs., and Ph.D all contain periods where the sentence does not stop. -> The words Dr., Mrs., and Ph.D all contain periods where the sentence does not stop EOS

1. We know how to compute similarly distance between two given strings using the edit distance algorithm.
   1. Please write down the distance matrix for the following strings:  
      String 1: Spokesman confirms  
      String 2: Spokeswoman said

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| s | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 13 | 12 | 11 | 12 | 11 | 10 | 9 | 10 | 11 | 12 |
| m | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 12 | 11 | 10 | 11 | 10 | 9 | 10 | 11 | 10 | 11 |
| r | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 11 | 10 | 11 | 10 | 9 | 8 | 9 | 10 | 9 | 10 |
| i | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 10 | 9 | 10 | 9 | 8 | 7 | 8 | 9 | 8 | 9 |
| f | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 9 | 8 | 9 | 8 | 7 | 6 | 7 | 8 | 9 | 10 |
| n | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 8 | 7 | 8 | 7 | 6 | 5 | 6 | 7 | 8 | 9 |
| o | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 7 | 6 | 7 | 6 | 5 | 4 | 5 | 6 | 7 | 8 |
| c | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 6 | 7 | 6 | 5 | 4 | 3 | 4 | 5 | 6 | 7 |
|  | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 5 | 6 | 5 | 4 | 3 | 2 | 3 | 4 | 5 | 6 |
| n | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 4 | 5 | 4 | 3 | 2 | 3 | 4 | 5 | 6 | 7 |
| a | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 3 | 4 | 3 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| m | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 2 | 3 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| s | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| e | 5 | 4 | 3 | 2 | 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| k | 4 | 3 | 2 | 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| o | 3 | 2 | 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| p | 2 | 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| S | 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|  | # | S | p | o | k | e | s | w | o | m | a | n |  | s | a | i | d |

* 1. List down all the operations you need to perform. Please show backtracing matrix to validate your answer for the above example strings.  
       
     Insert w, Insert o, Delete c, Delete o, Replace n with s, Replace f with a, Delete r, Delete m, Replace s with d. 1 + 1 + 1 + 1 + 2 + 2 + 1 + 1 + 2 = **12**  
     Spokesman confirms -> Spokes\_\_man confirms  
     Spokeswoman said -> Spokeswoman \_\_sai\_\_d

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| s | 18 | 17↓ | 16↓ | 15↓ | 14↓ | 13↓ | 12↓ | 13↙ | 12↓ | 11↓ | 12↙ | 11↓ | 10↓ | 9↙ | 10← | 11↓← | 12↙ |
| m | 17 | 16↓ | 15↓ | 14↓ | 13↓ | 12↓ | 11↓ | 12↙ | 11↓ | 10↙ | 11↓ | 10↓ | 9↓ | 10↙ | 11↙ | 10↓ | 11↙ |
| r | 16 | 15↓ | 14↓ | 13↓ | 12↓ | 11↓ | 10↓ | 11↙ | 10↓ | 11↙ | 10↓ | 9↓ | 8↓ | 9↙ | 10↙ | 9↓ | 10↙ |
| i | 15 | 14↓ | 13↓ | 12↓ | 11↓ | 10↓ | 9↓ | 10↙ | 9↓ | 10↙ | 9↓ | 8↓ | 7↓ | 8↙ | 9↙ | 8↙ | 9← |
| f | 14 | 13↓ | 12↓ | 11↓ | 10↓ | 9↓ | 8↓ | 9↙ | 8↓ | 9↙ | 8↓ | 7↓ | 6↓ | 7↙ | 8↙ | 9↙ | 10↙ |
| n | 13 | 12↓ | 11↓ | 10↓ | 9↓ | 8↓ | 7↓ | 8↙ | 7↓ | 8↙ | 7↓ | 6↓ | 5↓ | 6↙ | 7↙ | 8↙ | 9↙ |
| o | 12 | 11↓ | 10↓ | 9↓ | 8↓ | 7↓ | 6↓ | 7↙ | 6↙ | 7↓← | 6↓ | 5↓ | 4↓ | 5↙ | 6↙ | 7↙ | 8↙ |
| c | 11 | 10↓ | 9↓ | 8↓ | 7↓ | 6↓ | 5↓ | 6↙ | 7↙ | 6↓ | 5↓ | 4↓ | 3↓ | 4↙ | 5↙ | 6↙ | 7↙ |
|  | 10 | 9↓ | 8↓ | 7↓ | 6↓ | 5↓ | 4↓ | 5↙ | 6↙ | 5↓ | 4↓ | 3↓ | 2↙ | 3← | 4← | 5← | 6← |
| n | 9 | 8↓ | 7↓ | 6↓ | 5↓ | 4↓ | 3↓ | 4↙ | 5↙ | 4↓ | 3↓ | 2↙ | 3← | 4← | 5← | 6← | 7← |
| a | 8 | 7↓ | 6↓ | 5↓ | 4↓ | 3↓ | 2↓ | 3↙ | 4↙ | 3↓ | 2↙ | 3← | 4← | 5← | 6← | 7← | 8← |
| m | 7 | 6↓ | 5↓ | 4↓ | 3↓ | 2↓ | 1↓ | 2↙ | 3↙ | 2↙ | 3← | 4← | 5← | 6← | 7← | 8← | 9← |
| s | 6 | 5↓ | 4↓ | 3↓ | 2↓ | 1↓ | 0↙ | 1← | 2← | 3← | 4← | 5← | 6← | 7← | 8← | 9← | 10← |
| e | 5 | 4↓ | 3↓ | 2↓ | 1↓ | 0↙ | 1← | 2← | 3← | 4← | 5← | 6← | 7← | 8← | 9← | 10← | 11← |
| k | 4 | 3↓ | 2↓ | 1↓ | 0↙ | 1← | 2← | 3← | 4← | 5← | 6← | 7← | 8← | 9← | 10← | 11← | 12← |
| o | 3 | 2↓ | 1↓ | 0↙ | 1← | 2← | 3← | 4← | 5← | 6← | 7← | 8← | 9← | 10← | 11← | 12← | 13← |
| p | 2 | 1↓ | 0↙ | 1← | 2← | 3← | 4← | 5← | 6← | 7← | 8← | 9← | 10← | 11← | 12← | 13← | 14← |
| S | 1 | 0↙ | 1← | 2← | 3← | 4← | 5← | 6← | 7← | 8← | 9← | 10← | 11← | 12← | 13← | 14← | 15← |
| # | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|  | # | S | p | o | k | e | s | w | o | m | a | n |  | s | a | i | d |

1. Please formulate your language model for the following text. Show the details of your LM formulation.  
   “The day was grey and bitter cold, and the dogs would not take the scent. The big black bitch had taken one sniff at the bear tracks, backed off, and skulked back to the pack with her tail between her legs.”
   1. Unigram model  
        
      P(<s>) = 1/48, P(the) = 6/48, P(day) = 1/48, P(was) = 1/48, P(grey) = 1/48, P(and) = 3/48, P(bitter) = 1/48, P(cold) = 1/48, P(,) = 3/48, P(dogs) = 1/48, P(would) = 1/48, P(not) = 1/48, P(take) = 1/48, P(scent) = 1/48, P(.) = 2/48, P(big) = 1/48, P(black) = 1/48, P(bitch) = 1/48, P(had) = 1/48, P(taken) = 1/48, P(one) = 1/48, P(sniff) = 1/48, P(at) = 1/48, P(bear) = 1/48, P(tracks) = 1/48, P(backed) = 1/48, P(off) = 1/48, P(skulked) = 1/48, P(back) = 1/48, P(to) = 1/48, P(pack) = 1/48, P(with) = 1/48, P(her) = 2/48, P(tail) = 1/48, P(between) = 1/48, P(legs) = 1/48, P(</s>) = 1/48
   2. Bigram model  
        
      P(<s>|<s>) = 0/1, P(<s>|the) = 0/6, P(<s>|day) = 0/1, P(<s>|was) = 0/1, P(<s>|grey) = 0/1, P(<s>|and) = 0/3, P(<s>|bitter) = 0/1, P(<s>|cold) = 0/1, P(<s>|,) = 0/3, P(<s>|dogs) = 0/1, P(<s>|would) = 0/1, P(<s>|not) = 0/1, P(<s>|take) = 0/1, P(<s>|scent) = 0/1, P(<s>|.) = 0/2, P(<s>|big) = 0/1, P(<s>|black) = 0/1, P(<s>|bitch) = 0/1, P(<s>|had) = 0/1, P(<s>|taken) = 0/1, P(<s>|one) = 0/1, P(<s>|sniff) = 0/1, P(<s>|at) = 0/1, P(<s>|bear) = 0/1, P(<s>|tracks) = 0/1, P(<s>|backed) = 0/1, P(<s>|off) = 0/1, P(<s>|skulked) = 0/1, P(<s>|back) = 0/1, P(<s>|to) = 0/1, P(<s>|pack) = 0/1, P(<s>|with) = 0/1, P(<s>|her) = 0/2, P(<s>|tail) = 0/1, P(<s>|between) = 0/1, P(<s>|legs) = 0/1, P(<s>|</s>) = 0/1  
        
      P(the|<s>) = 1/1, P(the|the) = 0/6, P(the|day) = 0/1, P(the|was) = 0/1, P(the|grey) = 0/1, P(the|and) = 1/3, P(the|bitter) = 0/1, P(the|cold) = 0/1, P(the|,) = 0/3, P(the|dogs) = 0/1, P(the|would) = 0/1, P(the|not) = 0/1, P(the|take) = 1/1, P(the|scent) = 0/1, P(the|.) = 0/2, P(the|big) = 0/1, P(the|black) = 0/1, P(the|bitch) = 0/1, P(the|had) = 0/1, P(the|taken) = 0/1, P(the|one) = 0/1, P(the|sniff) = 0/1, P(the|at) = 1/1, P(the|bear) = 0/1, P(the|tracks) = 0/1, P(the|backed) = 0/1, P(the|off) = 0/1, P(the|skulked) = 0/1, P(the|back) = 0/1, P(the|to) = 1/1, P(the|pack) = 0/1, P(the|with) = 0/1, P(the|her) = 0/2, P(the|tail) = 0/1, P(the|between) = 0/1, P(the|legs) = 0/1, P(the|</s>) = 0/1  
        
      P(day|<s>) = 0/1, P(day|the) = 1/6, P(day|day) = 0/1, P(day|was) = 0/1, P(day|grey) = 0/1, P(day|and) = 0/3, P(day|bitter) = 0/1, P(day|cold) = 0/1, P(day|,) = 0/3, P(day|dogs) = 0/1, P(day|would) = 0/1, P(day|not) = 0/1, P(day|take) = 0/1, P(day|scent) = 0/1, P(day|.) = 0/2, P(day|big) = 0/1, P(day|black) = 0/1, P(day|bitch) = 0/1, P(day|had) = 0/1, P(day|taken) = 0/1, P(day|one) = 0/1, P(day|sniff) = 0/1, P(day|at) = 0/1, P(day|bear) = 0/1, P(day|tracks) = 0/1, P(day|backed) = 0/1, P(day|off) = 0/1, P(day|skulked) = 0/1, P(day|back) = 0/1, P(day|to) = 0/1, P(day|pack) = 0/1, P(day|with) = 0/1, P(day|her) = 0/2, P(day|tail) = 0/1, P(day|between) = 0/1, P(day|legs) = 0/1, P(day|</s>) = 0/1  
        
      P(was|<s>) = 0/1, P(was|the) = 0/6, P(was|day) = 1/1, P(was|was) = 0/1, P(was|grey) = 0/1, P(was|and) = 0/3, P(was|bitter) = 0/1, P(was|cold) = 0/1, P(was|,) = 0/3, P(was|dogs) = 0/1, P(was|would) = 0/1, P(was|not) = 0/1, P(was|take) = 0/1, P(was|scent) = 0/1, P(was|.) = 0/2, P(was|big) = 0/1, P(was|black) = 0/1, P(was|bitch) = 0/1, P(was|had) = 0/1, P(was|taken) = 0/1, P(was|one) = 0/1, P(was|sniff) = 0/1, P(was|at) = 0/1, P(was|bear) = 0/1, P(was|tracks) = 0/1, P(was|backed) = 0/1, P(was|off) = 0/1, P(was|skulked) = 0/1, P(was|back) = 0/1, P(was|to) = 0/1, P(was|pack) = 0/1, P(was|with) = 0/1, P(was|her) = 0/2, P(was|tail) = 0/1, P(was|between) = 0/1, P(was|legs) = 0/1, P(was|</s>) = 0/1  
        
      P(grey|<s>) = 0/1, P(grey|the) = 0/6, P(grey|day) = 0/1, P(grey|was) = 1/1, P(grey|grey) = 0/1, P(grey|and) = 0/3, P(grey|bitter) = 0/1, P(grey|cold) = 0/1, P(grey|,) = 0/3, P(grey|dogs) = 0/1, P(grey|would) = 0/1, P(grey|not) = 0/1, P(grey|take) = 0/1, P(grey|scent) = 0/1, P(grey|.) = 0/2, P(grey|big) = 0/1, P(grey|black) = 0/1, P(grey|bitch) = 0/1, P(grey|had) = 0/1, P(grey|taken) = 0/1, P(grey|one) = 0/1, P(grey|sniff) = 0/1, P(grey|at) = 0/1, P(grey|bear) = 0/1, P(grey|tracks) = 0/1, P(grey|backed) = 0/1, P(grey|off) = 0/1, P(grey|skulked) = 0/1, P(grey|back) = 0/1, P(grey|to) = 0/1, P(grey|pack) = 0/1, P(grey|with) = 0/1, P(grey|her) = 0/2, P(grey|tail) = 0/1, P(grey|between) = 0/1, P(grey|legs) = 0/1, P(grey|</s>) = 0/1  
        
      P(and|<s>) = 0/1, P(and|the) = 0/6, P(and|day) = 0/1, P(and|was) = 0/1, P(and|grey) = 1/1, P(and|and) = 0/3, P(and|bitter) = 0/1, P(and|cold) = 0/1, P(and|,) = 0/3, P(and|dogs) = 0/1, P(and|would) = 0/1, P(and|not) = 0/1, P(and|take) = 0/1, P(and|scent) = 0/1, P(and|.) = 0/2, P(and|big) = 0/1, P(and|black) = 0/1, P(and|bitch) = 0/1, P(and|had) = 0/1, P(and|taken) = 0/1, P(and|one) = 0/1, P(and|sniff) = 0/1, P(and|at) = 0/1, P(and|bear) = 0/1, P(and|tracks) = 0/1, P(and|backed) = 0/1, P(and|off) = 0/1, P(and|skulked) = 0/1, P(and|back) = 0/1, P(and|to) = 0/1, P(and|pack) = 0/1, P(and|with) = 0/1, P(and|her) = 0/2, P(and|tail) = 0/1, P(and|between) = 0/1, P(and|legs) = 0/1, P(and|</s>) = 0/1  
        
      P(bitter|<s>) = 0/1, P(bitter|the) = 0/6, P(bitter|day) = 0/1, P(bitter|was) = 0/1, P(bitter|grey) = 0/1, P(bitter|and) = 1/3, P(bitter|bitter) = 0/1, P(bitter|cold) = 0/1, P(bitter|,) = 0/3, P(bitter|dogs) = 0/1, P(bitter|would) = 0/1, P(bitter|not) = 0/1, P(bitter|take) = 0/1, P(bitter|scent) = 0/1, P(bitter|.) = 0/2, P(bitter|big) = 0/1, P(bitter|black) = 0/1, P(bitter|bitch) = 0/1, P(bitter|had) = 0/1, P(bitter|taken) = 0/1, P(bitter|one) = 0/1, P(bitter|sniff) = 0/1, P(bitter|at) = 0/1, P(bitter|bear) = 0/1, P(bitter|tracks) = 0/1, P(bitter|backed) = 0/1, P(bitter|off) = 0/1, P(bitter|skulked) = 0/1, P(bitter|back) = 0/1, P(bitter|to) = 0/1, P(bitter|pack) = 0/1, P(bitter|with) = 0/1, P(bitter|her) = 0/2, P(bitter|tail) = 0/1, P(bitter|between) = 0/1, P(bitter|legs) = 0/1, P(bitter|</s>) = 0/1  
        
      P(cold|<s>) = 0/1, P(cold|the) = 0/6, P(cold|day) = 0/1, P(cold|was) = 0/1, P(cold|grey) = 0/1, P(cold|and) = 0/3, P(cold|bitter) = 0/1, P(cold|cold) = 0/1, P(cold|,) = 0/3, P(cold|dogs) = 0/1, P(cold|would) = 0/1, P(cold|not) = 0/1, P(cold|take) = 0/1, P(cold|scent) = 0/1, P(cold|.) = 0/2, P(cold|big) = 0/1, P(cold|black) = 0/1, P(cold|bitch) = 0/1, P(cold|had) = 0/1, P(cold|taken) = 0/1, P(cold|one) = 0/1, P(cold|sniff) = 0/1, P(cold|at) = 0/1, P(cold|bear) = 0/1, P(cold|tracks) = 0/1, P(cold|backed) = 0/1, P(cold|off) = 0/1, P(cold|skulked) = 0/1, P(cold|back) = 0/1, P(cold|to) = 0/1, P(cold|pack) = 0/1, P(cold|with) = 0/1, P(cold|her) = 0/2, P(cold|tail) = 0/1, P(cold|between) = 0/1, P(cold|legs) = 0/1, P(cold|</s>) = 0/1  
        
      P(,|<s>) = 0/1, P(,|the) = 0/6, P(,|day) = 0/1, P(,|was) = 0/1, P(,|grey) = 0/1, P(,|and) = 0/3, P(,|bitter) = 0/1, P(,|cold) = 1/1, P(,|,) = 0/3, P(,|dogs) = 0/1, P(,|would) = 0/1, P(,|not) = 0/1, P(,|take) = 0/1, P(,|scent) = 0/1, P(,|.) = 0/2, P(,|big) = 0/1, P(,|black) = 0/1, P(,|bitch) = 0/1, P(,|had) = 0/1, P(,|taken) = 0/1, P(,|one) = 0/1, P(,|sniff) = 0/1, P(,|at) = 0/1, P(,|bear) = 0/1, P(,|tracks) = 1/1, P(,|backed) = 0/1, P(,|off) = 1/1, P(,|skulked) = 0/1, P(,|back) = 0/1, P(,|to) = 0/1, P(,|pack) = 0/1, P(,|with) = 0/1, P(,|her) = 0/2, P(,|tail) = 0/1, P(,|between) = 0/1, P(,|legs) = 0/1, P(,|</s>) = 0/1  
        
      P(dogs|<s>) = 0/1, P(dogs|the) = 1/6, P(dogs|day) = 0/1, P(dogs|was) = 0/1, P(dogs|grey) = 0/1, P(dogs|and) = 0/3, P(dogs|bitter) = 0/1, P(dogs|cold) = 0/1, P(dogs|,) = 0/3, P(dogs|dogs) = 0/1, P(dogs|would) = 0/1, P(dogs|not) = 0/1, P(dogs|take) = 0/1, P(dogs|scent) = 0/1, P(dogs|.) = 0/2, P(dogs|big) = 0/1, P(dogs|black) = 0/1, P(dogs|bitch) = 0/1, P(dogs|had) = 0/1, P(dogs|taken) = 0/1, P(dogs|one) = 0/1, P(dogs|sniff) = 0/1, P(dogs|at) = 0/1, P(dogs|bear) = 0/1, P(dogs|tracks) = 0/1, P(dogs|backed) = 0/1, P(dogs|off) = 0/1, P(dogs|skulked) = 0/1, P(dogs|back) = 0/1, P(dogs|to) = 0/1, P(dogs|pack) = 0/1, P(dogs|with) = 0/1, P(dogs|her) = 0/2, P(dogs|tail) = 0/1, P(dogs|between) = 0/1, P(dogs|legs) = 0/1, P(dogs|</s>) = 0/1  
        
      P(would|<s>) = 0/1, P(would|the) = 0/6, P(would|day) = 0/1, P(would|was) = 0/1, P(would|grey) = 0/1, P(would|and) = 0/3, P(would|bitter) = 0/1, P(would|cold) = 0/1, P(would|,) = 0/3, P(would|dogs) = 1/1, P(would|would) = 0/1, P(would|not) = 0/1, P(would|take) = 0/1, P(would|scent) = 0/1, P(would|.) = 0/2, P(would|big) = 0/1, P(would|black) = 0/1, P(would|bitch) = 0/1, P(would|had) = 0/1, P(would|taken) = 0/1, P(would|one) = 0/1, P(would|sniff) = 0/1, P(would|at) = 0/1, P(would|bear) = 0/1, P(would|tracks) = 0/1, P(would|backed) = 0/1, P(would|off) = 0/1, P(would|skulked) = 0/1, P(would|back) = 0/1, P(would|to) = 0/1, P(would|pack) = 0/1, P(would|with) = 0/1, P(would|her) = 0/2, P(would|tail) = 0/1, P(would|between) = 0/1, P(would|legs) = 0/1, P(would|</s>) = 0/1  
        
      P(not|<s>) = 0/1, P(not|the) = 0/6, P(not|day) = 0/1, P(not|was) = 0/1, P(not|grey) = 0/1, P(not|and) = 0/3, P(not|bitter) = 0/1, P(not|cold) = 0/1, P(not|,) = 0/3, P(not|dogs) = 0/1, P(not|would) = 1/1, P(not|not) = 0/1, P(not|take) = 0/1, P(not|scent) = 0/1, P(not|.) = 0/2, P(not|big) = 0/1, P(not|black) = 0/1, P(not|bitch) = 0/1, P(not|had) = 0/1, P(not|taken) = 0/1, P(not|one) = 0/1, P(not|sniff) = 0/1, P(not|at) = 0/1, P(not|bear) = 0/1, P(not|tracks) = 0/1, P(not|backed) = 0/1, P(not|off) = 0/1, P(not|skulked) = 0/1, P(not|back) = 0/1, P(not|to) = 0/1, P(not|pack) = 0/1, P(not|with) = 0/1, P(not|her) = 0/2, P(not|tail) = 0/1, P(not|between) = 0/1, P(not|legs) = 0/1, P(not|</s>) = 0/1  
        
      P(take|<s>) = 0/1, P(take|the) = 0/6, P(take|day) = 0/1, P(take|was) = 0/1, P(take|grey) = 0/1, P(take|and) = 0/3, P(take|bitter) = 0/1, P(take|cold) = 0/1, P(take|,) = 0/3, P(take|dogs) = 0/1, P(take|would) = 0/1, P(take|not) = 1/1, P(take|take) = 0/1, P(take|scent) = 0/1, P(take|.) = 0/2, P(take|big) = 0/1, P(take|black) = 0/1, P(take|bitch) = 0/1, P(take|had) = 0/1, P(take|taken) = 0/1, P(take|one) = 0/1, P(take|sniff) = 0/1, P(take|at) = 0/1, P(take|bear) = 0/1, P(take|tracks) = 0/1, P(take|backed) = 0/1, P(take|off) = 0/1, P(take|skulked) = 0/1, P(take|back) = 0/1, P(take|to) = 0/1, P(take|pack) = 0/1, P(take|with) = 0/1, P(take|her) = 0/2, P(take|tail) = 0/1, P(take|between) = 0/1, P(take|legs) = 0/1, P(take|</s>) = 0/1  
        
      P(scent|<s>) = 0/1, P(scent|the) = 0/6, P(scent|day) = 0/1, P(scent|was) = 0/1, P(scent|grey) = 0/1, P(scent|and) = 0/3, P(scent|bitter) = 0/1, P(scent|cold) = 0/1, P(scent|,) = 0/3, P(scent|dogs) = 0/1, P(scent|would) = 0/1, P(scent|not) = 0/1, P(scent|take) = 0/1, P(scent|scent) = 0/1, P(scent|.) = 0/2, P(scent|big) = 0/1, P(scent|black) = 0/1, P(scent|bitch) = 0/1, P(scent|had) = 0/1, P(scent|taken) = 0/1, P(scent|one) = 0/1, P(scent|sniff) = 0/1, P(scent|at) = 0/1, P(scent|bear) = 0/1, P(scent|tracks) = 0/1, P(scent|backed) = 0/1, P(scent|off) = 0/1, P(scent|skulked) = 0/1, P(scent|back) = 0/1, P(scent|to) = 0/1, P(scent|pack) = 0/1, P(scent|with) = 0/1, P(scent|her) = 0/2, P(scent|tail) = 0/1, P(scent|between) = 0/1, P(scent|legs) = 0/1, P(scent|</s>) = 0/1  
        
      P(.|<s>) = 0/1, P(.|the) = 0/6, P(.|day) = 0/1, P(.|was) = 0/1, P(.|grey) = 0/1, P(.|and) = 0/3, P(.|bitter) = 0/1, P(.|cold) = 0/1, P(.|,) = 0/3, P(.|dogs) = 0/1, P(.|would) = 0/1, P(.|not) = 0/1, P(.|take) = 0/1, P(.|scent) = 1/1, P(.|.) = 0/2, P(.|big) = 0/1, P(.|black) = 0/1, P(.|bitch) = 0/1, P(.|had) = 0/1, P(.|taken) = 0/1, P(.|one) = 0/1, P(.|sniff) = 0/1, P(.|at) = 0/1, P(.|bear) = 0/1, P(.|tracks) = 0/1, P(.|backed) = 0/1, P(.|off) = 0/1, P(.|skulked) = 0/1, P(.|back) = 0/1, P(.|to) = 0/1, P(.|pack) = 0/1, P(.|with) = 0/1, P(.|her) = 0/2, P(.|tail) = 0/1, P(.|between) = 0/1, P(.|legs) = 1/1, P(.|</s>) = 0/1  
        
      P(big|<s>) = 0/1, P(big|the) = 1/6, P(big|day) = 0/1, P(big|was) = 0/1, P(big|grey) = 0/1, P(big|and) = 0/3, P(big|bitter) = 0/1, P(big|cold) = 0/1, P(big|,) = 0/3, P(big|dogs) = 0/1, P(big|would) = 0/1, P(big|not) = 0/1, P(big|take) = 0/1, P(big|scent) = 0/1, P(big|.) = 0/2, P(big|big) = 0/1, P(big|black) = 0/1, P(big|bitch) = 0/1, P(big|had) = 0/1, P(big|taken) = 0/1, P(big|one) = 0/1, P(big|sniff) = 0/1, P(big|at) = 0/1, P(big|bear) = 0/1, P(big|tracks) = 0/1, P(big|backed) = 0/1, P(big|off) = 0/1, P(big|skulked) = 0/1, P(big|back) = 0/1, P(big|to) = 0/1, P(big|pack) = 0/1, P(big|with) = 0/1, P(big|her) = 0/2, P(big|tail) = 0/1, P(big|between) = 0/1, P(big|legs) = 0/1, P(big|</s>) = 0/1  
        
      P(black|<s>) = 0/1, P(black|the) = 0/6, P(black|day) = 0/1, P(black|was) = 0/1, P(black|grey) = 0/1, P(black|and) = 0/3, P(black|bitter) = 0/1, P(black|cold) = 0/1, P(black|,) = 0/3, P(black|dogs) = 0/1, P(black|would) = 0/1, P(black|not) = 0/1, P(black|take) = 0/1, P(black|scent) = 0/1, P(black|.) = 0/2, P(black|big) = 1/1, P(black|black) = 0/1, P(black|bitch) = 0/1, P(black|had) = 0/1, P(black|taken) = 0/1, P(black|one) = 0/1, P(black|sniff) = 0/1, P(black|at) = 0/1, P(black|bear) = 0/1, P(black|tracks) = 0/1, P(black|backed) = 0/1, P(black|off) = 0/1, P(black|skulked) = 0/1, P(black|back) = 0/1, P(black|to) = 0/1, P(black|pack) = 0/1, P(black|with) = 0/1, P(black|her) = 0/2, P(black|tail) = 0/1, P(black|between) = 0/1, P(black|legs) = 0/1, P(black|</s>) = 0/1  
        
      P(bitch|<s>) = 0/1, P(bitch|the) = 0/6, P(bitch|day) = 0/1, P(bitch|was) = 0/1, P(bitch|grey) = 0/1, P(bitch|and) = 0/3, P(bitch|bitter) = 0/1, P(bitch|cold) = 0/1, P(bitch|,) = 0/3, P(bitch|dogs) = 0/1, P(bitch|would) = 0/1, P(bitch|not) = 0/1, P(bitch|take) = 0/1, P(bitch|scent) = 0/1, P(bitch|.) = 0/2, P(bitch|big) = 0/1, P(bitch|black) = 1/1, P(bitch|bitch) = 0/1, P(bitch|had) = 0/1, P(bitch|taken) = 0/1, P(bitch|one) = 0/1, P(bitch|sniff) = 0/1, P(bitch|at) = 0/1, P(bitch|bear) = 0/1, P(bitch|tracks) = 0/1, P(bitch|backed) = 0/1, P(bitch|off) = 0/1, P(bitch|skulked) = 0/1, P(bitch|back) = 0/1, P(bitch|to) = 0/1, P(bitch|pack) = 0/1, P(bitch|with) = 0/1, P(bitch|her) = 0/2, P(bitch|tail) = 0/1, P(bitch|between) = 0/1, P(bitch|legs) = 0/1, P(bitch|</s>) = 0/1  
        
      P(had|<s>) = 0/1, P(had|the) = 0/6, P(had|day) = 0/1, P(had|was) = 0/1, P(had|grey) = 0/1, P(had|and) = 0/3, P(had|bitter) = 0/1, P(had|cold) = 0/1, P(had|,) = 0/3, P(had|dogs) = 0/1, P(had|would) = 0/1, P(had|not) = 0/1, P(had|take) = 0/1, P(had|scent) = 0/1, P(had|.) = 0/2, P(had|big) = 0/1, P(had|black) = 0/1, P(had|bitch) = 1/1, P(had|had) = 0/1, P(had|taken) = 0/1, P(had|one) = 0/1, P(had|sniff) = 0/1, P(had|at) = 0/1, P(had|bear) = 0/1, P(had|tracks) = 0/1, P(had|backed) = 0/1, P(had|off) = 0/1, P(had|skulked) = 0/1, P(had|back) = 0/1, P(had|to) = 0/1, P(had|pack) = 0/1, P(had|with) = 0/1, P(had|her) = 0/2, P(had|tail) = 0/1, P(had|between) = 0/1, P(had|legs) = 0/1, P(had|</s>) = 0/1  
        
      P(taken|<s>) = 0/1, P(taken|the) = 0/6, P(taken|day) = 0/1, P(taken|was) = 0/1, P(taken|grey) = 0/1, P(taken|and) = 0/3, P(taken|bitter) = 0/1, P(taken|cold) = 0/1, P(taken|,) = 0/3, P(taken|dogs) = 0/1, P(taken|would) = 0/1, P(taken|not) = 0/1, P(taken|take) = 0/1, P(taken|scent) = 0/1, P(taken|.) = 0/2, P(taken|big) = 0/1, P(taken|black) = 0/1, P(taken|bitch) = 0/1, P(taken|had) = 1/1, P(taken|taken) = 0/1, P(taken|one) = 0/1, P(taken|sniff) = 0/1, P(taken|at) = 0/1, P(taken|bear) = 0/1, P(taken|tracks) = 0/1, P(taken|backed) = 0/1, P(taken|off) = 0/1, P(taken|skulked) = 0/1, P(taken|back) = 0/1, P(taken|to) = 0/1, P(taken|pack) = 0/1, P(taken|with) = 0/1, P(taken|her) = 0/2, P(taken|tail) = 0/1, P(taken|between) = 0/1, P(taken|legs) = 0/1, P(taken|</s>) = 0/1  
        
      P(one|<s>) = 0/1, P(one|the) = 0/6, P(one|day) = 0/1, P(one|was) = 0/1, P(one|grey) = 0/1, P(one|and) = 0/3, P(one|bitter) = 0/1, P(one|cold) = 0/1, P(one|,) = 0/3, P(one|dogs) = 0/1, P(one|would) = 0/1, P(one|not) = 0/1, P(one|take) = 0/1, P(one|scent) = 0/1, P(one|.) = 0/2, P(one|big) = 0/1, P(one|black) = 0/1, P(one|bitch) = 0/1, P(one|had) = 0/1, P(one|taken) = 1/1, P(one|one) = 0/1, P(one|sniff) = 0/1, P(one|at) = 0/1, P(one|bear) = 0/1, P(one|tracks) = 0/1, P(one|backed) = 0/1, P(one|off) = 0/1, P(one|skulked) = 0/1, P(one|back) = 0/1, P(one|to) = 0/1, P(one|pack) = 0/1, P(one|with) = 0/1, P(one|her) = 0/2, P(one|tail) = 0/1, P(one|between) = 0/1, P(one|legs) = 0/1, P(one|</s>) = 0/1  
        
      P(sniff|<s>) = 0/1, P(sniff|the) = 0/6, P(sniff|day) = 0/1, P(sniff|was) = 0/1, P(sniff|grey) = 0/1, P(sniff|and) = 0/3, P(sniff|bitter) = 0/1, P(sniff|cold) = 0/1, P(sniff|,) = 0/3, P(sniff|dogs) = 0/1, P(sniff|would) = 0/1, P(sniff|not) = 0/1, P(sniff|take) = 0/1, P(sniff|scent) = 0/1, P(sniff|.) = 0/2, P(sniff|big) = 0/1, P(sniff|black) = 0/1, P(sniff|bitch) = 0/1, P(sniff|had) = 0/1, P(sniff|taken) = 0/1, P(sniff|one) = 1/1, P(sniff|sniff) = 0/1, P(sniff|at) = 0/1, P(sniff|bear) = 0/1, P(sniff|tracks) = 0/1, P(sniff|backed) = 0/1, P(sniff|off) = 0/1, P(sniff|skulked) = 0/1, P(sniff|back) = 0/1, P(sniff|to) = 0/1, P(sniff|pack) = 0/1, P(sniff|with) = 0/1, P(sniff|her) = 0/2, P(sniff|tail) = 0/1, P(sniff|between) = 0/1, P(sniff|legs) = 0/1, P(sniff|</s>) = 0/1  
        
      P(at|<s>) = 0/1, P(at|the) = 0/6, P(at|day) = 0/1, P(at|was) = 0/1, P(at|grey) = 0/1, P(at|and) = 0/3, P(at|bitter) = 0/1, P(at|cold) = 0/1, P(at|,) = 0/3, P(at|dogs) = 0/1, P(at|would) = 0/1, P(at|not) = 0/1, P(at|take) = 0/1, P(at|scent) = 0/1, P(at|.) = 0/2, P(at|big) = 0/1, P(at|black) = 0/1, P(at|bitch) = 0/1, P(at|had) = 0/1, P(at|taken) = 0/1, P(at|one) = 0/1, P(at|sniff) = 1/1, P(at|at) = 0/1, P(at|bear) = 0/1, P(at|tracks) = 0/1, P(at|backed) = 0/1, P(at|off) = 0/1, P(at|skulked) = 0/1, P(at|back) = 0/1, P(at|to) = 0/1, P(at|pack) = 0/1, P(at|with) = 0/1, P(at|her) = 0/2, P(at|tail) = 0/1, P(at|between) = 0/1, P(at|legs) = 0/1, P(at|</s>) = 0/1  
        
      P(bear|<s>) = 0/1, P(bear|the) = 1/6, P(bear|day) = 0/1, P(bear|was) = 0/1, P(bear|grey) = 0/1, P(bear|and) = 0/3, P(bear|bitter) = 0/1, P(bear|cold) = 0/1, P(bear|,) = 0/3, P(bear|dogs) = 0/1, P(bear|would) = 0/1, P(bear|not) = 0/1, P(bear|take) = 0/1, P(bear|scent) = 0/1, P(bear|.) = 0/2, P(bear|big) = 0/1, P(bear|black) = 0/1, P(bear|bitch) = 0/1, P(bear|had) = 0/1, P(bear|taken) = 0/1, P(bear|one) = 0/1, P(bear|sniff) = 0/1, P(bear|at) = 0/1, P(bear|bear) = 0/1, P(bear|tracks) = 0/1, P(bear|backed) = 0/1, P(bear|off) = 0/1, P(bear|skulked) = 0/1, P(bear|back) = 0/1, P(bear|to) = 0/1, P(bear|pack) = 0/1, P(bear|with) = 0/1, P(bear|her) = 0/2, P(bear|tail) = 0/1, P(bear|between) = 0/1, P(bear|legs) = 0/1, P(bear|</s>) = 0/1  
        
      P(tracks|<s>) = 0/1, P(tracks|the) = 0/6, P(tracks|day) = 0/1, P(tracks|was) = 0/1, P(tracks|grey) = 0/1, P(tracks|and) = 0/3, P(tracks|bitter) = 0/1, P(tracks|cold) = 0/1, P(tracks|,) = 0/3, P(tracks|dogs) = 0/1, P(tracks|would) = 0/1, P(tracks|not) = 0/1, P(tracks|take) = 0/1, P(tracks|scent) = 0/1, P(tracks|.) = 0/2, P(tracks|big) = 0/1, P(tracks|black) = 0/1, P(tracks|bitch) = 0/1, P(tracks|had) = 0/1, P(tracks|taken) = 0/1, P(tracks|one) = 0/1, P(tracks|sniff) = 0/1, P(tracks|at) = 0/1, P(tracks|bear) = 0/1, P(tracks|tracks) = 0/1, P(tracks|backed) = 0/1, P(tracks|off) = 0/1, P(tracks|skulked) = 0/1, P(tracks|back) = 0/1, P(tracks|to) = 0/1, P(tracks|pack) = 0/1, P(tracks|with) = 0/1, P(tracks|her) = 0/2, P(tracks|tail) = 0/1, P(tracks|between) = 0/1, P(tracks|legs) = 0/1, P(tracks|</s>) = 0/1  
        
      P(backed|<s>) = 0/1, P(backed|the) = 0/6, P(backed|day) = 0/1, P(backed|was) = 0/1, P(backed|grey) = 0/1, P(backed|and) = 0/3, P(backed|bitter) = 0/1, P(backed|cold) = 0/1, P(backed|,) = 0/3, P(backed|dogs) = 0/1, P(backed|would) = 0/1, P(backed|not) = 0/1, P(backed|take) = 0/1, P(backed|scent) = 0/1, P(backed|.) = 0/2, P(backed|big) = 0/1, P(backed|black) = 0/1, P(backed|bitch) = 0/1, P(backed|had) = 0/1, P(backed|taken) = 0/1, P(backed|one) = 0/1, P(backed|sniff) = 0/1, P(backed|at) = 0/1, P(backed|bear) = 0/1, P(backed|tracks) = 0/1, P(backed|backed) = 0/1, P(backed|off) = 0/1, P(backed|skulked) = 0/1, P(backed|back) = 0/1, P(backed|to) = 0/1, P(backed|pack) = 0/1, P(backed|with) = 0/1, P(backed|her) = 0/2, P(backed|tail) = 0/1, P(backed|between) = 0/1, P(backed|legs) = 0/1, P(backed|</s>) = 0/1  
        
      P(off|<s>) = 0/1, P(off|the) = 0/6, P(off|day) = 0/1, P(off|was) = 0/1, P(off|grey) = 0/1, P(off|and) = 0/3, P(off|bitter) = 0/1, P(off|cold) = 0/1, P(off|,) = 0/3, P(off|dogs) = 0/1, P(off|would) = 0/1, P(off|not) = 0/1, P(off|take) = 0/1, P(off|scent) = 0/1, P(off|.) = 0/2, P(off|big) = 0/1, P(off|black) = 0/1, P(off|bitch) = 0/1, P(off|had) = 0/1, P(off|taken) = 0/1, P(off|one) = 0/1, P(off|sniff) = 0/1, P(off|at) = 0/1, P(off|bear) = 0/1, P(off|tracks) = 0/1, P(off|backed) = 0/1, P(off|off) = 0/1, P(off|skulked) = 0/1, P(off|back) = 0/1, P(off|to) = 0/1, P(off|pack) = 0/1, P(off|with) = 0/1, P(off|her) = 0/2, P(off|tail) = 0/1, P(off|between) = 0/1, P(off|legs) = 0/1, P(off|</s>) = 0/1  
        
      P(skulked|<s>) = 0/1, P(skulked|the) = 0/6, P(skulked|day) = 0/1, P(skulked|was) = 0/1, P(skulked|grey) = 0/1, P(skulked|and) = 1/3, P(skulked|bitter) = 0/1, P(skulked|cold) = 0/1, P(skulked|,) = 0/3, P(skulked|dogs) = 0/1, P(skulked|would) = 0/1, P(skulked|not) = 0/1, P(skulked|take) = 0/1, P(skulked|scent) = 0/1, P(skulked|.) = 0/2, P(skulked|big) = 0/1, P(skulked|black) = 0/1, P(skulked|bitch) = 0/1, P(skulked|had) = 0/1, P(skulked|taken) = 0/1, P(skulked|one) = 0/1, P(skulked|sniff) = 0/1, P(skulked|at) = 0/1, P(skulked|bear) = 0/1, P(skulked|tracks) = 0/1, P(skulked|backed) = 0/1, P(skulked|off) = 0/1, P(skulked|skulked) = 0/1, P(skulked|back) = 0/1, P(skulked|to) = 0/1, P(skulked|pack) = 0/1, P(skulked|with) = 0/1, P(skulked|her) = 0/2, P(skulked|tail) = 0/1, P(skulked|between) = 0/1, P(skulked|legs) = 0/1, P(skulked|</s>) = 0/1  
        
      P(back|<s>) = 0/1, P(back|the) = 0/6, P(back|day) = 0/1, P(back|was) = 0/1, P(back|grey) = 0/1, P(back|and) = 0/3, P(back|bitter) = 0/1, P(back|cold) = 0/1, P(back|,) = 0/3, P(back|dogs) = 0/1, P(back|would) = 0/1, P(back|not) = 0/1, P(back|take) = 0/1, P(back|scent) = 0/1, P(back|.) = 0/2, P(back|big) = 0/1, P(back|black) = 0/1, P(back|bitch) = 0/1, P(back|had) = 0/1, P(back|taken) = 0/1, P(back|one) = 0/1, P(back|sniff) = 0/1, P(back|at) = 0/1, P(back|bear) = 0/1, P(back|tracks) = 0/1, P(back|backed) = 0/1, P(back|off) = 0/1, P(back|skulked) = 1/1, P(back|back) = 0/1, P(back|to) = 0/1, P(back|pack) = 0/1, P(back|with) = 0/1, P(back|her) = 0/2, P(back|tail) = 0/1, P(back|between) = 0/1, P(back|legs) = 0/1, P(back|</s>) = 0/1  
        
      P(to|<s>) = 0/1, P(to|the) = 0/6, P(to|day) = 0/1, P(to|was) = 0/1, P(to|grey) = 0/1, P(to|and) = 0/3, P(to|bitter) = 0/1, P(to|cold) = 0/1, P(to|,) = 0/3, P(to|dogs) = 0/1, P(to|would) = 0/1, P(to|not) = 0/1, P(to|take) = 0/1, P(to|scent) = 0/1, P(to|.) = 0/2, P(to|big) = 0/1, P(to|black) = 0/1, P(to|bitch) = 0/1, P(to|had) = 0/1, P(to|taken) = 0/1, P(to|one) = 0/1, P(to|sniff) = 0/1, P(to|at) = 0/1, P(to|bear) = 0/1, P(to|tracks) = 0/1, P(to|backed) = 0/1, P(to|off) = 0/1, P(to|skulked) = 0/1, P(to|back) = 1/1, P(to|to) = 0/1, P(to|pack) = 0/1, P(to|with) = 0/1, P(to|her) = 0/2, P(to|tail) = 0/1, P(to|between) = 0/1, P(to|legs) = 0/1, P(to|</s>) = 0/1  
        
      P(pack|<s>) = 0/1, P(pack|the) = 1/6, P(pack|day) = 0/1, P(pack|was) = 0/1, P(pack|grey) = 0/1, P(pack|and) = 0/3, P(pack|bitter) = 0/1, P(pack|cold) = 0/1, P(pack|,) = 0/3, P(pack|dogs) = 0/1, P(pack|would) = 0/1, P(pack|not) = 0/1, P(pack|take) = 0/1, P(pack|scent) = 0/1, P(pack|.) = 0/2, P(pack|big) = 0/1, P(pack|black) = 0/1, P(pack|bitch) = 0/1, P(pack|had) = 0/1, P(pack|taken) = 0/1, P(pack|one) = 0/1, P(pack|sniff) = 0/1, P(pack|at) = 0/1, P(pack|bear) = 0/1, P(pack|tracks) = 0/1, P(pack|backed) = 0/1, P(pack|off) = 0/1, P(pack|skulked) = 0/1, P(pack|back) = 0/1, P(pack|to) = 0/1, P(pack|pack) = 0/1, P(pack|with) = 0/1, P(pack|her) = 0/2, P(pack|tail) = 0/1, P(pack|between) = 0/1, P(pack|legs) = 0/1, P(pack|</s>) = 0/1  
        
      P(with|<s>) = 0/1, P(with|the) = 0/6, P(with|day) = 0/1, P(with|was) = 0/1, P(with|grey) = 0/1, P(with|and) = 0/3, P(with|bitter) = 0/1, P(with|cold) = 0/1, P(with|,) = 0/3, P(with|dogs) = 0/1, P(with|would) = 0/1, P(with|not) = 0/1, P(with|take) = 0/1, P(with|scent) = 0/1, P(with|.) = 0/2, P(with|big) = 0/1, P(with|black) = 0/1, P(with|bitch) = 0/1, P(with|had) = 0/1, P(with|taken) = 0/1, P(with|one) = 0/1, P(with|sniff) = 0/1, P(with|at) = 0/1, P(with|bear) = 0/1, P(with|tracks) = 0/1, P(with|backed) = 0/1, P(with|off) = 0/1, P(with|skulked) = 0/1, P(with|back) = 0/1, P(with|to) = 0/1, P(with|pack) = 1/1, P(with|with) = 0/1, P(with|her) = 0/2, P(with|tail) = 0/1, P(with|between) = 0/1, P(with|legs) = 0/1, P(with|</s>) = 0/1  
        
      P(her|<s>) = 0/1, P(her|the) = 0/6, P(her|day) = 0/1, P(her|was) = 0/1, P(her|grey) = 0/1, P(her|and) = 0/3, P(her|bitter) = 0/1, P(her|cold) = 0/1, P(her|,) = 0/3, P(her|dogs) = 0/1, P(her|would) = 0/1, P(her|not) = 0/1, P(her|take) = 0/1, P(her|scent) = 0/1, P(her|.) = 0/2, P(her|big) = 0/1, P(her|black) = 0/1, P(her|bitch) = 0/1, P(her|had) = 0/1, P(her|taken) = 0/1, P(her|one) = 0/1, P(her|sniff) = 0/1, P(her|at) = 0/1, P(her|bear) = 0/1, P(her|tracks) = 0/1, P(her|backed) = 0/1, P(her|off) = 0/1, P(her|skulked) = 0/1, P(her|back) = 0/1, P(her|to) = 0/1, P(her|pack) = 0/1, P(her|with) = 1/1, P(her|her) = 0/2, P(her|tail) = 0/1, P(her|between) = 1/1, P(her|legs) = 0/1, P(her|</s>) = 0/1  
        
      P(tail|<s>) = 0/1, P(tail|the) = 0/6, P(tail|day) = 0/1, P(tail|was) = 0/1, P(tail|grey) = 0/1, P(tail|and) = 0/3, P(tail|bitter) = 0/1, P(tail|cold) = 0/1, P(tail|,) = 0/3, P(tail|dogs) = 0/1, P(tail|would) = 0/1, P(tail|not) = 0/1, P(tail|take) = 0/1, P(tail|scent) = 0/1, P(tail|.) = 0/2, P(tail|big) = 0/1, P(tail|black) = 0/1, P(tail|bitch) = 0/1, P(tail|had) = 0/1, P(tail|taken) = 0/1, P(tail|one) = 0/1, P(tail|sniff) = 0/1, P(tail|at) = 0/1, P(tail|bear) = 0/1, P(tail|tracks) = 0/1, P(tail|backed) = 0/1, P(tail|off) = 0/1, P(tail|skulked) = 0/1, P(tail|back) = 0/1, P(tail|to) = 0/1, P(tail|pack) = 0/1, P(tail|with) = 0/1, P(tail|her) = 1/2, P(tail|tail) = 0/1, P(tail|between) = 0/1, P(tail|legs) = 0/1, P(tail|</s>) = 0/1  
        
      P(between|<s>) = 0/1, P(between|the) = 0/6, P(between|day) = 0/1, P(between|was) = 0/1, P(between|grey) = 0/1, P(between|and) = 0/3, P(between|bitter) = 0/1, P(between|cold) = 0/1, P(between|,) = 0/3, P(between|dogs) = 0/1, P(between|would) = 0/1, P(between|not) = 0/1, P(between|take) = 0/1, P(between|scent) = 0/1, P(between|.) = 0/2, P(between|big) = 0/1, P(between|black) = 0/1, P(between|bitch) = 0/1, P(between|had) = 0/1, P(between|taken) = 0/1, P(between|one) = 0/1, P(between|sniff) = 0/1, P(between|at) = 0/1, P(between|bear) = 0/1, P(between|tracks) = 0/1, P(between|backed) = 0/1, P(between|off) = 0/1, P(between|skulked) = 0/1, P(between|back) = 0/1, P(between|to) = 0/1, P(between|pack) = 0/1, P(between|with) = 0/1, P(between|her) = 0/2, P(between|tail) = 1/1, P(between|between) = 0/1, P(between|legs) = 0/1, P(between|</s>) = 0/1  
        
      P(legs|<s>) = 0/1, P(legs|the) = 0/6, P(legs|day) = 0/1, P(legs|was) = 0/1, P(legs|grey) = 0/1, P(legs|and) = 0/3, P(legs|bitter) = 0/1, P(legs|cold) = 0/1, P(legs|,) = 0/3, P(legs|dogs) = 0/1, P(legs|would) = 0/1, P(legs|not) = 0/1, P(legs|take) = 0/1, P(legs|scent) = 0/1, P(legs|.) = 0/2, P(legs|big) = 0/1, P(legs|black) = 0/1, P(legs|bitch) = 0/1, P(legs|had) = 0/1, P(legs|taken) = 0/1, P(legs|one) = 0/1, P(legs|sniff) = 0/1, P(legs|at) = 0/1, P(legs|bear) = 0/1, P(legs|tracks) = 0/1, P(legs|backed) = 0/1, P(legs|off) = 0/1, P(legs|skulked) = 0/1, P(legs|back) = 0/1, P(legs|to) = 0/1, P(legs|pack) = 0/1, P(legs|with) = 0/1, P(legs|her) = 0/2, P(legs|tail) = 0/1, P(legs|between) = 0/1, P(legs|legs) = 0/1, P(legs|</s>) = 0/1  
        
      P(</s>|<s>) = 0/1, P(</s>|the) = 0/6, P(</s>|day) = 0/1, P(</s>|was) = 0/1, P(</s>|grey) = 0/1, P(</s>|and) = 0/3, P(</s>|bitter) = 0/1, P(</s>|cold) = 0/1, P(</s>|,) = 0/3, P(</s>|dogs) = 0/1, P(</s>|would) = 0/1, P(</s>|not) = 0/1, P(</s>|take) = 0/1, P(</s>|scent) = 0/1, P(</s>|.) = 0/2, P(</s>|big) = 0/1, P(</s>|black) = 0/1, P(</s>|bitch) = 0/1, P(</s>|had) = 0/1, P(</s>|taken) = 0/1, P(</s>|one) = 0/1, P(</s>|sniff) = 0/1, P(</s>|at) = 0/1, P(</s>|bear) = 0/1, P(</s>|tracks) = 0/1, P(</s>|backed) = 0/1, P(</s>|off) = 0/1, P(</s>|skulked) = 0/1, P(</s>|back) = 0/1, P(</s>|to) = 0/1, P(</s>|pack) = 0/1, P(</s>|with) = 0/1, P(</s>|her) = 0/2, P(</s>|tail) = 0/1, P(</s>|between) = 0/1, P(</s>|legs) = 0/1, P(</s>|</s>) = 0/1
2. You are given a training set of 30 numbers that consists of 21 zeros and 1 each of the other digits 1-9. Now we see the following test set: 0 0 0 0 0 3 0 0 0 0. What is the unigram perplexity?  
     
   P(0) = 21/30, P(3) = 1/30  
   21/30 \* 21/30 \* 21/30 \* 21/30 \* 21/30 \* 1/30 \* 21/30 \* 21/30 \* 21/30 \* 21/30 = .0013  
   1/.0013 = 743.4280  
   743.4280 ^ 1/10 (10th root) = **1.93697**  
   The unigram complexity is 1.93697.