

Due: Thursday, January 20

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**Problem 1.**

A parse tree for the sentence "please eat that". The root node is "S", which branches into "p", "l", and "o". "p" branches into "p", which branches into "l". "l" branches into "a", "e", and "o". "a" branches into "n" and "y". "n" branches into "t" and "\$". "t" branches into "\$". "y" branches into "\$". "e" branches into "a", which branches into "\$" and "s". "\$" branches into "s", which branches into "e", which branches into "\$", which branches into "e". "o" branches into "t", which branches into "\$", which branches into "e".

- ### Problem 2.

A search tree diagram for a game. The root node is an open circle. It has four children: a leaf node labeled '2' (filled circle), an internal node (open circle), an internal node (open circle), and a leaf node labeled '5' (filled circle). The first internal node has two children: a leaf node labeled '0' (filled circle) and a leaf node labeled '3' (filled circle). The second internal node has two children: a leaf node labeled '1' (filled circle) and a leaf node labeled '4' (filled circle). Edges are labeled with letters 'a', 'b', 'c', 'd' and dollar signs '\$'.

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**Problem 3.**

Suppose a Bloom filter is designed using a bit array with  $c = 15$  buckets and  $k = 3$  hash functions. The objects below are inserted into the filter:

object	hash_1(x)	hash_2(x)	hash_3(x)
$x_1$	12	2	14
$x_2$	1	5	4
$x_3$	7	10	3
$x_4$	5	12	0
$x_5$	13	6	7
$x_6$	4	10	4

- a) Draw the Bloom filter by specifying the content of each bucket.
- b) Suppose a new element has the following hashes:

hash\_1(x): 5  
hash\_2(x): 3  
hash\_3(x): 7

When the Bloom filter is asked if  $x$  is an element, what does it return?

**Problem 4.**

Suppose a count-min sketch with  $k = 3$  rows and  $c = 5$  buckets in each row is designed. Assume that the following sequence of objects is inserted:

$$x_1, x_2, x_1, x_1, x_3, x_4, x_3, x_1, x_4, x_1, x_2$$

The values of each of the  $k$  hash functions on the objects is shown below.

object	hash_1(x)	hash_2(x)	hash_3(x)
$x_1$	1	2	3
$x_2$	4	2	0
$x_3$	4	1	3
$x_4$	3	3	4

- a) Draw the count-min sketch table by writing the count that is contained within each bucket after the above items are inserted.
- b) Suppose the count of item  $x_3$  is queried. What is returned?