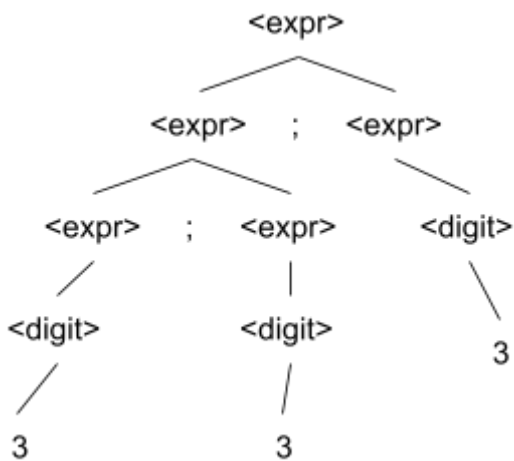


**Name: Prathmesh Sonawane**

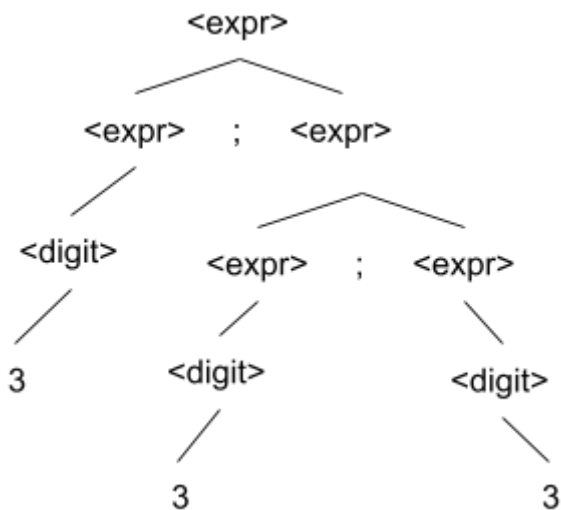
**Problem 1**

We can show the ambiguity of the grammar by finding multiple parse trees for a given expression. We can do so by finding the parse trees for the sentence **3;3;3**

**1st Parse Tree**



**2nd Parse Tree**



**Explanation:** Since there are multiple parse trees for the same given sentence, the given grammar is ambiguous.

## **Problem 2**

### Previous Grammar

$\langle \text{id} \rangle ::= a|b|c|\dots|z$

$\langle \text{dig} \rangle ::= 0|1|2|\dots|9$

$\langle \text{expr} \rangle ::= ()|\langle \text{dig} \rangle|\langle \text{id} \rangle$

$|\text{let } \langle \text{id} \rangle = \langle \text{expr} \rangle \text{ in } \langle \text{expr} \rangle$

$|\langle \text{expr} \rangle ; \langle \text{expr} \rangle$

$|\text{begin } \langle \text{expr} \rangle \text{ end}$

### **New Grammar that is unambiguous (Answer Below)**

$\langle \text{id} \rangle ::= a|b|c|\dots|z$

$\langle \text{dig} \rangle ::= 0|1|2|\dots|9$

$\langle \text{expr} \rangle ::= ()|\langle \text{dig} \rangle|\langle \text{id} \rangle$

$|\text{let } \langle \text{id} \rangle = \langle \text{expr} \rangle \text{ in } \langle \text{expr} \rangle$

$|\langle \rangle ; \langle \text{expr} \rangle$

$|\langle \text{digit} \rangle ; \langle \text{expr} \rangle$

$|\langle \text{id} \rangle ; \langle \text{expr} \rangle$

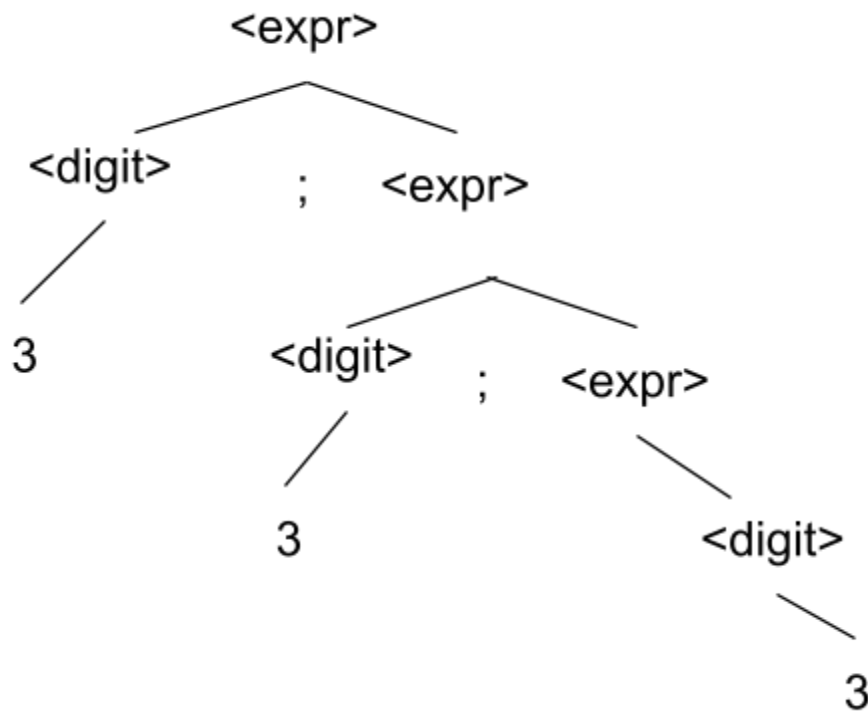
$|\text{let } \langle \text{id} \rangle = \langle \text{expr} \rangle \text{ in } \langle \text{expr} \rangle ; \langle \text{expr} \rangle$

$|\text{begin } \langle \text{expr} \rangle \text{ end } ; \langle \text{expr} \rangle$

$|\text{begin } \langle \text{expr} \rangle \text{ end}$

### Problem 3

We can show the unambiguity of the new grammar by finding just one possible parse tree for all given expressions. Here, we can retest our initial sentence **3;3;3**.



**Explanation:** For our given sentence **3;3;3**, with the modified grammar, there is only one possible parse tree. Thus, our grammar is unambiguous for this sentence. The ambiguity of the old grammar structure stemmed from the fact that  $\langle \text{expr} \rangle$  could turn into  $\langle \text{expr} \rangle ; \langle \text{expr} \rangle$ . This symmetry allowed multiple parse trees to be possible. With our improved grammar, this symmetry is broken, only allowing for one possible parse tree.