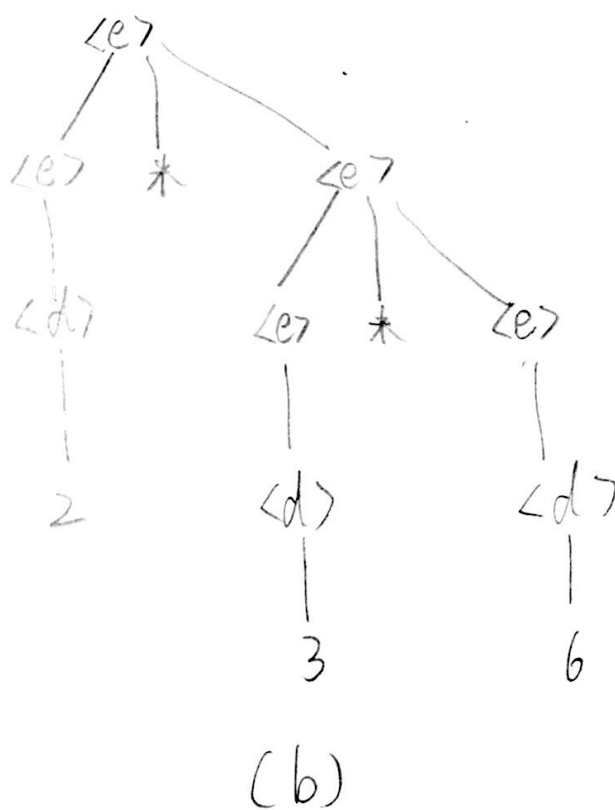
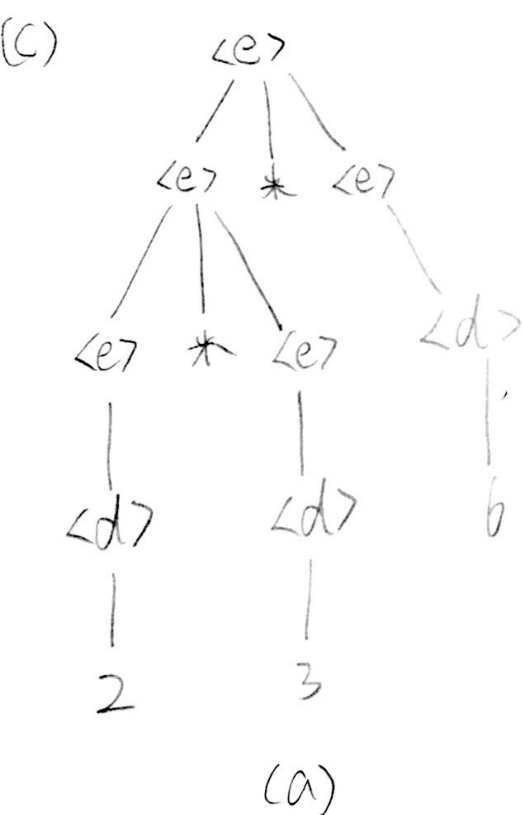


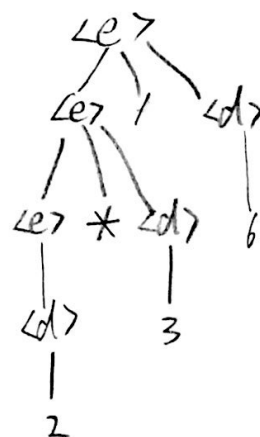
1. (a) $\langle e \rangle \rightarrow \langle e \rangle * \langle e \rangle \rightarrow \langle e \rangle * \langle e \rangle * \langle e \rangle \rightarrow \langle d \rangle * \langle e \rangle * \langle e \rangle$
 $\rightarrow 2 * \langle e \rangle * \langle e \rangle \rightarrow 2 * \langle d \rangle * \langle e \rangle \rightarrow 2 * 3 * \langle e \rangle$
 $\rightarrow 2 * 3 * \langle d \rangle \rightarrow 2 * 3 * 6$

(b) $\langle e \rangle \rightarrow \langle e \rangle * \langle e \rangle \rightarrow \langle e \rangle * \langle e \rangle * \langle e \rangle \rightarrow \langle e \rangle * \langle e \rangle * \langle d \rangle \rightarrow \langle e \rangle * \langle e \rangle * 6$
 $\rightarrow \langle e \rangle * \langle d \rangle * 6 \rightarrow \langle e \rangle * 3 * 6 \rightarrow \langle d \rangle * 3 * 6$
 $\rightarrow 2 * 3 * 6$



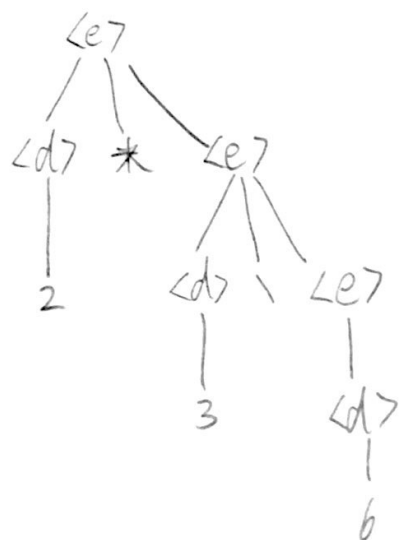
(d) Grammar: $\langle e \rangle \rightarrow \langle e \rangle * \langle d \rangle \mid \langle e \rangle / \langle d \rangle \mid \langle d \rangle$
 $\langle d \rangle \rightarrow 0 \mid 1 \mid 2 \mid \dots \mid 9$

Reason: For all terminal strings, there's at most one parse tree.



(c) Grammar: $\langle e \rangle \rightarrow \langle d \rangle / \langle e \rangle \mid \langle d \rangle * \langle e \rangle \mid \langle d \rangle$
 $\langle d \rangle \rightarrow 0 \mid 1 \mid 2 \mid 3 \dots 9$

Parse Tree:



2. Solution: $\langle e \rangle \rightarrow \langle n \rangle \mid \langle e \rangle, \langle n \rangle$
 $\langle n \rangle \rightarrow \langle d \rangle \mid \langle n \rangle \langle d \rangle$
 $\langle d \rangle \rightarrow 0 \mid 1 \mid 2 \mid 3 \dots 9$

In this grammar, each step always replace left most non-terminal. So, for all terminal strings there's at most one parse tree

3. Solution: $\langle e \rangle \rightarrow \langle t \rangle \mid \langle e \rangle + \langle t \rangle \mid \langle e \rangle - \langle t \rangle$
 $\langle t \rangle \rightarrow \langle d \rangle \mid \langle t \rangle$
 $\langle d \rangle \rightarrow 0 \mid 1 \mid 2 \dots 9$

4. Solution: $\langle m \rangle \rightarrow \langle l \rangle \{ \langle l \rangle \langle d \rangle \} @ \langle middle \rangle . \langle end \rangle$
 $\langle l \rangle \rightarrow a \mid b \mid c \dots z \mid A \mid B \mid C \dots Z$
 $\langle d \rangle \rightarrow 0 \mid 1 \mid 2 \dots 9$

$\langle end \rangle \rightarrow org \mid edu \mid com$

$\langle middle \rangle \rightarrow \{ \langle l \rangle \langle d \rangle \} \{ \langle l \rangle \langle d \rangle \} \{ \langle l \rangle \langle d \rangle \} \mid \langle middle \rangle \{ \langle l \rangle \langle d \rangle \} \{ \langle l \rangle \langle d \rangle \} \{ \langle l \rangle \langle d \rangle \}$

5. Solution: $\langle n \rangle \rightarrow \langle d \rangle \{ \langle zero \rangle \mid \langle d \rangle \}$
 $\langle d \rangle \rightarrow 1 \mid 2 \mid 3 \mid 4 \dots 9$
 $\langle zero \rangle \rightarrow 0$

6. Solution: $\langle \text{expr} \rangle \rightarrow \langle \text{int} \rangle \mid -\langle \text{int} \rangle \mid \langle \text{int} \rangle . \langle \text{int} \rangle \mid -\langle \text{int} \rangle . \langle \text{int} \rangle$
 $\langle \text{int} \rangle \rightarrow \langle \text{digit} \rangle \mid \langle \text{int} \rangle \langle \text{digit} \rangle$
 $\langle \text{digit} \rangle \rightarrow 0 \mid 1 \mid 2 \mid \dots \mid 9$