ORIGINAL GRAMMAR:

$\langle id \rangle$ ::= a | b | c | ... | z

$\langle dig \rangle$ ::= 0 | 1 | 2 | ... | 9

$\langle expr \rangle$ ::= () | $\langle dig \rangle$ | $\langle id \rangle$
  | let $\langle id \rangle$ = $\langle expr \rangle$ in $\langle expr \rangle$
  | $\langle expr \rangle$; $\langle expr \rangle$
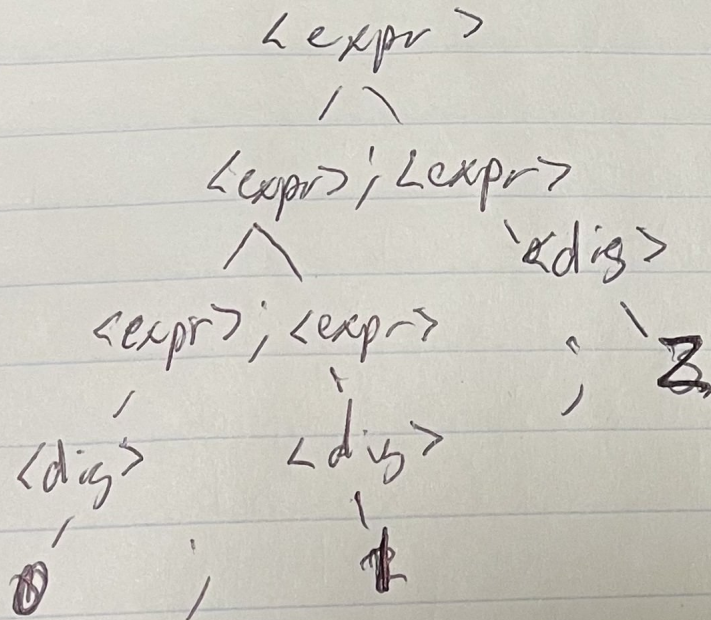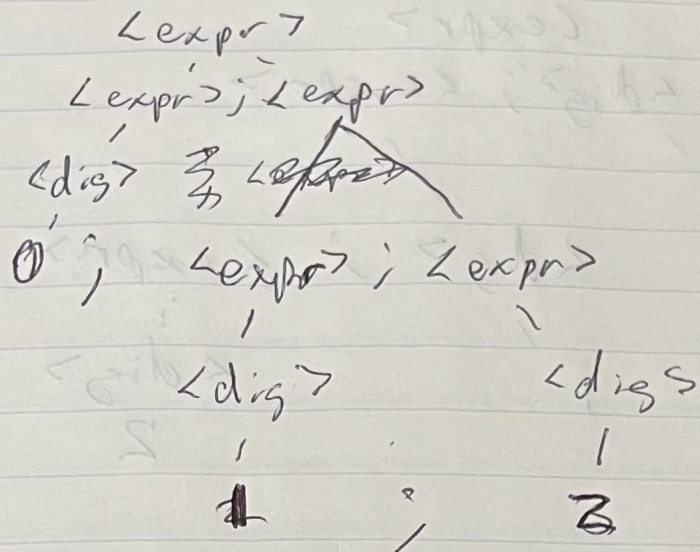 | begin $\langle expr \rangle$ end

QUESTION 1: Demonstrate the grammar above is ambiguous.
Sentence: 0 ; 1 ; 2. This can be derived in multiple ways.

$$< expr >$$
$$< expr >; < expr >$$
$$< dig >; < expr >$$
$$0; < expr >$$
$$0; < expr >; < expr >$$
$$0; < dig >; < expr >$$
$$0; 1; < expr >$$
$$0; 1; < dig >$$
$$0; 1; 2$$

OR

$$< expr >$$
$$< expr >; < expr >$$
$$< expr >; < dig >$$
$$< expr >; 2$$
$$< expr >; < expr >; 2$$
$$< expr >; < dig >; 2$$
$$< expr >; 1; 2$$
$$< dig >; 1; 2$$
$$0; 1; 2$$

1

Sentence: 0; 1; 2

```
                <expr>
           <expr> ; <expr>
        <dig>    3      <expr>
         0    ;      <expr> ; <expr>
                      <dig>        <dig>
                        |            |
                        1     ;      2
```

```
                <expr>
                 /\
            <expr> ; <expr>
              /\              <dig>
        <expr> ; <expr>      ;   2
          |        |
       <dig>     <dig>
          |        |
          0    ;    1
```

QUESTION 3: Modify this grammar to remove the ambiguity.

MODIFIED GRAMMAR:

$\langle id \rangle ::=$ a | b | c | ... | z

$\langle dig \rangle ::=$ 0 | 1 | 2 | ... | 9

$\langle expr \rangle ::=$ () | $\langle dig \rangle$ | $\langle id \rangle$
   | let $\langle id \rangle$ in $\langle expr \rangle$
   | () ; $\langle expr \rangle$
   | $\langle dig \rangle$; $\langle expr \rangle$
   | $\langle id \rangle$; $\langle expr \rangle$
   | let $\langle id \rangle$ in $\langle expr \rangle$; $\langle expr \rangle$
   | begin $\langle expr \rangle$ end ; $\langle expr \rangle$
   | begin $\langle expr \rangle$ end

MODIFIED GRAMMAR:

$\langle id \rangle ::= $ a | b | c | ... | z

$\langle dig \rangle ::= $ 0 | 1 | 2 | ... | 9

$\langle expr \rangle ::= $ () | $\langle dig \rangle$ | $\langle id \rangle$
   | let $\langle id \rangle$ in $\langle expr \rangle$ in $\langle expr \rangle$
   | () ; $\langle expr \rangle$
   | $\langle dig \rangle$; $\langle expr \rangle$
   | $\langle id \rangle$; $\langle expr \rangle$
   | let $\langle id \rangle$ in $\langle expr \rangle$ in $\langle expr \rangle$; $\langle expr \rangle$
   | begin $\langle expr \rangle$ end ; $\langle expr \rangle$
   | begin $\langle expr \rangle$ end

QUESTION 3: Demonstrate the revised grammar fixes the ambiguity.
Sentence: 0 ; 1 ; 2

$$< expr >$$
$$< dig >; < expr >$$
$$0; < expr >$$
$$0; < dig >; < expr >$$
$$0; 1; < expr >$$
$$0; 1; < dig >$$
$$0; 1; 2$$

4

Sentence: 0 ; 1 ; 2

$$\langle expr \rangle$$

$$\langle dig \rangle ; \langle expr \rangle$$

0

$$\langle dig \rangle ; \langle expr \rangle$$

1

$$\langle dig \rangle$$

2