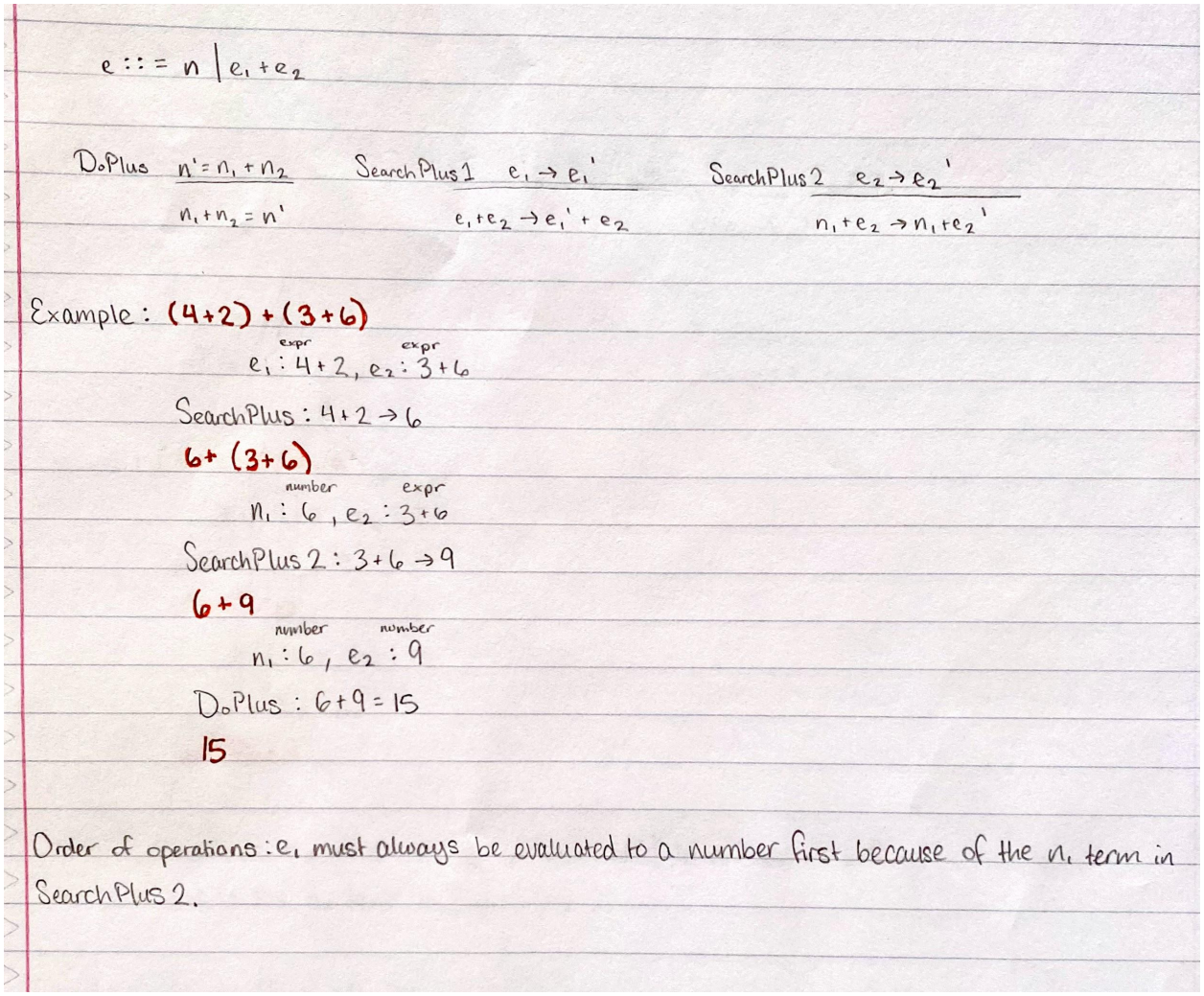
1. Write a set of inference rules that allow us to work through a simple addition example.



2. Write a set of inference rules such that the evaluation of e1 / e2 short-circuits if e2 is zero.

$e ::= n \mid x \mid e_1 + e_2 \mid e_1 / e_2 \mid e_1 - e_2$

$$\text{DoZeroDiv}\ \frac{n_2 = 0}{e_1 / n_2 \rightarrow \text{undefined}} \qquad \text{DoDiv}\ \frac{n' = n_1 / n_2 \quad n_2 \neq 0}{n_1 / n_2 \rightarrow n'}$$

$$\text{SearchDiv1}\ \frac{e_2 \rightarrow e_2'}{e_1 / e_2 \rightarrow e_1 / e_2'} \qquad \text{SearchDiv2}\ \frac{e_1 \rightarrow e_1'}{e_1 / n_2 \rightarrow e_1' / n_2}$$

Example: (4+2) / (3-3)

e_1 : 4+2 (expr), e_2 : 3-3 (expr)

SearchDiv1 : 3 - 3 → 0

(4+2) / 0

e_1 : 4+2 (expr), n_2 : 0 (number)

DoZeroDiv : $n_2 = 0$

undefined

Order of operations: e_2 must always be evaluated to a number before e_1 can start evaluating due to the n_2 term in SearchDiv 2.

Short-circuiting: If $n_2 = 0$, the evaluation can return early using DoZeroDiv and does not have to evaluate e_1 at all as seen in the example above.