

$$1. \quad \frac{}{N} \quad \frac{Nx}{Nx1} \quad \frac{Nx}{x- = x} \quad \frac{Ny}{-y = -y} \quad \frac{x-y = z}{x1-y = z1}$$

$$2. \quad \begin{array}{c} \frac{}{N} \\ \frac{}{N1} \\ \frac{}{N11} \\ \frac{}{1 \cdot 1 = 1} \\ \frac{}{1 \cdot 1 = 1} \\ \frac{}{11 \cdot 1 = 11} \\ \frac{}{11 \cdot 11 \cdot 1 = 111} \\ \frac{}{111 \cdot 11 \cdot 1 = 1111} \end{array}$$

3.

4. No. According to the formal system MU of Hofstadter, the way to get MU is having MIII and use  $\frac{MIII}{\mu}$  which means using 3 I. However, the number of I producing from the rule is always not divisible by 3.

$$\begin{array}{c} \frac{}{MI} \\ \frac{}{MII} \\ \frac{}{MIII} \\ \frac{}{MIIII} \\ \frac{}{MIIIIII} \end{array} \begin{array}{l} \text{axiom} \rightarrow \text{number of I is 1 which isn't divisible by 3} \\ \text{rule 2} \\ \text{rule 2} \\ \text{rule 2} \end{array} \left. \vphantom{\begin{array}{c} \frac{}{MI} \\ \frac{}{MII} \\ \frac{}{MIII} \\ \frac{}{MIIII} \\ \frac{}{MIIIIII} \end{array}} \right\} \text{number of I is doubling which isn't divisible by 3}$$

So the rule can't produce MIII, can't produce MU either.

9.

$$\begin{array}{c}
 \begin{array}{ccc}
 \begin{array}{c} \overline{P} \\ \hline FP \end{array} & \begin{array}{c} \overline{P} \\ \hline FP \\ \hline FNP \\ \hline FCNPN \end{array} & \begin{array}{c} \overline{P} \\ \hline FP \end{array}
 \end{array} \\
 \hline
 \text{ThCCPCNPPCCCNPPPCPP} & & \text{ThCPCNPP} \\
 \hline
 \text{ThCCCNPPPCPP} & & \text{ThCCNPP} \\
 \hline
 \text{ThCPP}
 \end{array}$$

which  $\text{ThCPP} = P \rightarrow P$