1. (15 points) Consider the following language:

$$e ::=$$ *Expressions*

n	number (integer)
set x e	set variable
read x	read variable
inc x	increment operator
e then e	then expression
test e e	test expression
loop e e	loop
crash	crash expression

$$x ::=$$ *Variables*

The big-step operational semantics relation evaluates an expression to a **number**.

$$e, \sigma \Downarrow n, \sigma'$$

Consider the following language and big-step operational semantics:

$$e ::=$$ *Expressions*

v	value
if (e) then (e) else (e)	if expression
rotate e	rotate expression

$$v ::=$$ *Values*

red	red
green	green
blue	blue

$$[\text{IF-RED}] \quad \frac{\begin{array}{c} e_1 \Downarrow v_1 \\ v_1 = \texttt{red} \\ e_3 \Downarrow v_3 \end{array}}{\texttt{if } (e_1) \texttt{ then } (e_2) \texttt{ else } (e_3) \Downarrow v_3}$$

$$[\text{IF-OTHER}] \quad \frac{\begin{array}{c} e_1 \Downarrow v_1 \\ v_1 \neq \texttt{red} \\ e_2 \Downarrow v_2 \end{array}}{\texttt{if } (e_1) \texttt{ then } (e_2) \texttt{ else } (e_3) \Downarrow v_2}$$

$$[\text{ROT-RED}] \quad \frac{\begin{array}{c} e_1 \Downarrow v_1 \\ v_1 \Downarrow \texttt{red} \end{array}}{\texttt{rotate } e_1 \Downarrow \texttt{green}}$$

$$[\text{ROT-GREEN}] \quad \frac{\begin{array}{c} e_1 \Downarrow v_1 \\ v_1 \Downarrow \texttt{green} \end{array}}{\texttt{rotate } e_1 \Downarrow \texttt{blue}}$$

$$[\text{ROT-BLUE}] \quad \frac{\begin{array}{c} e_1 \Downarrow v_1 \\ v_1 \Downarrow \texttt{blue} \end{array}}{\texttt{rotate } e_1 \Downarrow \texttt{red}}$$