## Part A

#### Exercise 10

- a) Let x be a variable. Then, either x is a local variable, or x is a global variable
- d) The expression e evaluates to value v. When e is evaluated, there are no variables, global or local, that are changed when e is evaluated.

### Exercise 11

- a) Even if  $x \notin \xi$ , there exists an expression e so that,  $\langle e, \xi, \phi, \rho \rangle \Downarrow \langle v, \xi', \phi, \rho' \rangle$  holds true.
- c) There exists an expression e so that  $\langle e, \xi, \phi, \rho \rangle \Downarrow \langle v, \xi, \phi, \rho' \rangle$  is true.
- d) There exists an expression e so that  $\langle e, \xi, \phi, \rho \rangle \Downarrow \langle v, \xi', \phi, \rho' \rangle$  (with no new variables  $\in \xi$ ) is true.

#### Exercise R

The alternative WhileEnd rule of Impcore is effectively the same, since the value "0" is found where "v1" is originally found. In this new rule, e1 still evaluates to "0", meaning that "v1" is still 0 as well.

The alternative FormalAssign rule of Impcore are not the same. The difference is that the original rule specifies that  $\rho$  will change because a new mapping is being added. In this new rule,  $\rho$  is not specified that it WILL change, it only states that it MAY change. Thus, it is possible that the mapping of x is not changed in this new rule, while it is required in the original one. The new binding hides previous bindings of x. An example code which will behave different with both rules is (set x 5), where x is already bound to another value.

## Part B

## Exercise 16

a)

b)

$$x \not\in dom \ \xi \quad x \not\in dom \ \rho$$

$$< VAR(x), \xi, \phi, \rho > \psi < 0, \xi'(x \Rightarrow 0), \phi, \rho >$$

$$x \not\in dom \ \xi \quad x \not\in dom \ \rho \quad < e, \xi, \rho, \phi > \psi < v, \xi', \phi, \rho' >$$

$$< SET(x, e), \xi, \phi, \rho > \psi < v, \xi'(x \Rightarrow v), \phi, \rho' >$$

$$x \not\in dom \ \xi \quad x \not\in dom \ \rho$$

$$< VAR(x), \xi, \phi, \rho > \psi < 0, \xi, \phi, \rho'(x \Rightarrow 0) >$$

$$x \not\in dom \ \xi \quad x \not\in dom \ \rho$$

$$< VAR(x), \xi, \phi, \rho > \psi < 0, \xi, \phi, \rho'(x \Rightarrow 0) >$$

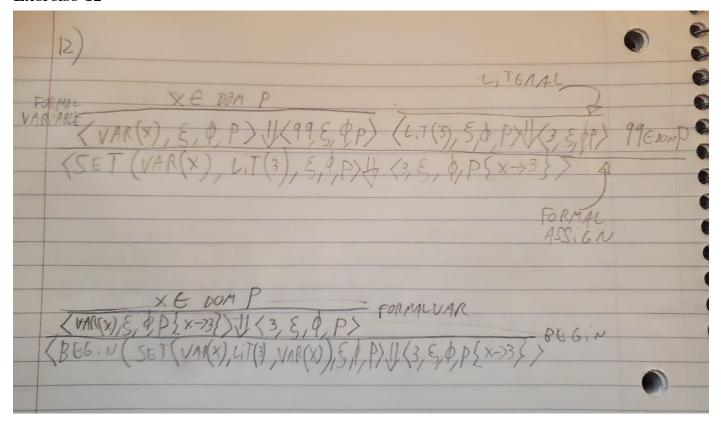
$$< SET(x, e), \xi, \phi, \rho > \psi < v, \xi', \phi, \rho'(x \Rightarrow v) >$$

c)

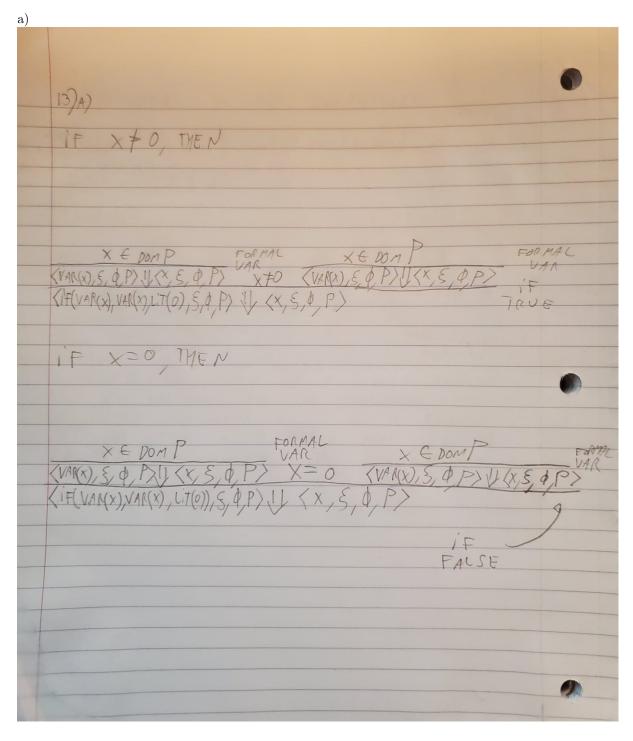
I think I prefer the changes in part b), since it doesn't create global variables but rather local ones. It is common practice to never use global variables, which can be used in very small programs, but not at all when programs are expanded, which is the reason some languages like Java don't even have global variables. Thus, making sure that the amount of global variables is close to 0 is important, and the rules in part b) serve this purpose better, although I can see the rules in part a) being used if its used for a small program.

# PART C

# Exercise 12



### Exercise 13



#### Exercise F

