

Problem 1.

Let $\rho = [x=[20], y=[15], z=[10]]$.

$(\text{value-of } \langle\langle z \rangle\rangle \rho) = 10, (\text{value-of } \langle\langle y \rangle\rangle \rho) = 15, (\text{value-of } \langle\langle -(z, y) \rangle\rangle \rho) = -5$
 $(\text{value-of } \langle\langle \text{zero?}(-(z, y)) \rangle\rangle \rho) = (\text{bool-val } \#f)$
 $(\text{value-of } \langle\langle \text{if zero?}(-(z, y)) \text{ then } -(x, z) \text{ else } -(12, x) \rangle\rangle \rho) = -(12, x)$
 $(\text{value-of } \langle\langle -(12, x) \rangle\rangle \rho) = -8$

Problem 2.

Let $\rho_0 = [x=[20], y=[15], z=[10]]$.

1. $(\text{value-of } \langle\langle \text{let } n = 15 \text{ in if zero?}(-(x, n)) \text{ then } -(x, y) \text{ else } -(-(z, n), -(y, x)) \rangle\rangle \rho_0)$

$= (\text{value-of } \langle\langle \text{if zero?}(-(x, n)) \text{ then } -(x, y) \text{ else } -(-(z, n), -(y, x)) \rangle\rangle [n=[15]] \rho_0)$

2. Let $\rho_1 = [n=[15]] \rho_0$.

3. $= (\text{if } (\text{expval} \rightarrow \text{bool } (\text{value-of } \langle\langle \text{zero?}(-(x, n)) \rangle\rangle \rho_1))$
 $\quad (\text{value-of } \langle\langle -(x, y) \rangle\rangle \rho_1)$
 $\quad (\text{value-of } \langle\langle -(-(z, n), -(y, x)) \rangle\rangle \rho_1))$

$= (\text{if } (\text{expval} \rightarrow \text{bool } (\text{bool-val } \#f))$
 $\quad (\text{value-of } \langle\langle -(x, y) \rangle\rangle \rho_1)$
 $\quad (\text{value-of } \langle\langle -(-(z, n), -(y, x)) \rangle\rangle \rho_1))$

$= (\text{if } \#f (\text{value-of } \langle\langle -(x, y) \rangle\rangle \rho_1) (\text{value-of } \langle\langle -(-(z, n), -(y, x)) \rangle\rangle \rho_1))$

4. $= (\text{value-of } \langle\langle -(-(z, n), -(y, x)) \rangle\rangle \rho_1)$

5 & 6. $= [(- [(value-of \langle\langle -(z, n) \rangle\rangle \rho_1)] [(value-of \langle\langle -(y, x) \rangle\rangle \rho_1)])]$

$= [(- [-5] [-5])]$

7. $= [0]$

Problem 3.

$(\text{app-exp} \rightarrow \text{rator} = (\text{lambda-exp} \rightarrow \text{bound-var} = (\text{identifier} \rightarrow f),$
 $\quad \text{lambda-exp} \rightarrow \text{body} = (\text{app-exp} \rightarrow \text{rator} = (\text{identifier} \rightarrow f),$
 $\quad \quad \text{app-exp} \rightarrow \text{rand} = (\text{identifier} \rightarrow x))),$
 $\text{app-exp} \rightarrow \text{rand} = (\text{identifier} \rightarrow y))$