Not having a good time with the mathpartir package here.

Exercise 4.1

Calls to `g` declare a reference `counter`, set its contents, then return its contents. The information between calls is lost because `counter` is different on each call. That is, the reference data structure represents a different location. The first program was made such that the environment of the closure had access to `counter`, and thus was able to reference that variable.

Exercise 4.2

$$\frac{\texttt{(value-of}\ \ exp_1\ \ \rho\ \ \sigma_0\texttt{)} = \texttt{(}val_1\texttt{,}\ \sigma_1\texttt{)}}{\begin{array}{c}\texttt{(value-of (zero?-exp}\ \ exp_1\texttt{)}\ \ \rho\ \ \sigma_0\texttt{)} = \\ \texttt{((bool-val \#t),}\ \sigma_1\texttt{)}\ \ \text{if}\ \ \lfloor val_1 \rfloor = 0 \\ \texttt{((bool-val \#f),}\ \sigma_1\texttt{)}\ \ \text{if}\ \ \lfloor val_1 \rfloor \neq 0\end{array}}$$

Exercise 4.3

$$\frac{\begin{array}{c}\texttt{(value-of}\ \ exp_1\ \ \rho\ \ \sigma_0\texttt{)} = \texttt{(}val_1\texttt{,}\ \sigma_1\texttt{)} \\ \texttt{(value-of}\ \ exp_2\ \ \rho\ \ \sigma_1\texttt{)} = \texttt{(}val_2\texttt{,}\ \sigma_2\texttt{)}\end{array}}{\begin{array}{c}\texttt{(value-of (call-exp}\ \ exp_1\ \ exp_2\texttt{)}\ \ \rho\ \ \sigma_0\texttt{)} \\ = \texttt{(apply-procedure (expval->proc}\ \ val_1\texttt{)}\ \ val_2\ \ \sigma_2\texttt{)}\end{array}}$$

$$\frac{val_1 = \texttt{(procedure}\ \ var\ \ body\ \ \rho\texttt{)}}{\begin{array}{c}\texttt{(apply-procedure}\ \ val_1\ \ val_2\ \ \rho_0\texttt{)} \\ = \texttt{(value-of}\ \ body\ \ [var = val_2]\rho\ \ \sigma_0\texttt{)}\end{array}}$$

Exercise 4.4

$$\frac{\begin{array}{c}(\texttt{value-of}\ \ exp_1\ \ \rho\ \ \sigma_0) = (val_1, \sigma_1) \\ \vdots \\ (\texttt{value-of}\ \ exp_n\ \ \rho\ \ \sigma_{n-1}) = (val_n, \sigma_n)\end{array}}{(\texttt{value-of}\ \ (\texttt{begin}\ \ exp_1 \ldots exp_n)\ \ \rho\ \ \sigma_0) = (val_n, \sigma_n)}$$

Exercise 4.5

$$\frac{\begin{array}{c}(\texttt{value-of}\ \ exp_1\ \ \rho\ \ \sigma_0) = (val_1, \sigma_1) \\ \vdots \\ (\texttt{value-of}\ \ exp_n\ \ \rho\ \ \sigma_{n-1}) = (val_n, \sigma_n)\end{array}}{\begin{array}{c}(\texttt{value-of}\ \ (\texttt{list-exp}\ \ exp_1 \ldots exp_n)\ \ \rho\ \ \sigma_0) \\ = ((\texttt{pair-val}\ \ val_1\ \ (\ldots (\texttt{pair-val}\ \ val_n\ \ (\texttt{emptylist-val}))\ \ldots)), \sigma_n)\end{array}}$$

Exercise 4.6

$$\frac{\begin{array}{c}(\texttt{value-of}\ \ exp_1\ \ \rho\ \ \sigma_0) = (l, \sigma_1) \\ (\texttt{value-of}\ \ exp_2\ \ \rho\ \ \sigma_1) = (val, \sigma_2)\end{array}}{(\texttt{value-of}\ \ (\texttt{setref-exp}\ \ exp_1\ \ exp_2)\ \ \rho\ \ \sigma_0) = (val, [l = val]\sigma_2)}$$

Exercise 4.7

$$\frac{\begin{array}{c}(\texttt{value-of}\ \ exp_1\ \ \rho\ \ \sigma_0) = (l, \sigma_1) \\ (\texttt{value-of}\ \ exp_2\ \ \rho\ \ \sigma_1) = (val, \sigma_2)\end{array}}{(\texttt{value-of}\ \ (\texttt{setref-exp}\ \ exp_1\ \ exp_2)\ \ \rho\ \ \sigma_0) = (\sigma_0(l), [l = val]\sigma_2)}$$