Exercise 2

1. What are the free names and free variables of the following processes?

   (a) $(\nu\, a)(\overline{x}\langle a\rangle \mid b(x).\overline{x}\langle b\rangle)$

   (b) $(\nu\, b)(\overline{a}\langle x\rangle \mid \overline{a}\langle c\rangle \mid (\nu\, a)y(x).\overline{b}\langle y\rangle)$

   (c) $(\nu\, c)(\overline{x}\langle x\rangle \mid !x(y).\overline{y}\langle c\rangle)$

2. Substitutions:

   (a) Apply $((\nu\, b)!\overline{b}\langle x\rangle \mid !(\nu\, a)\overline{b}\langle a\rangle)\{^{a}/_{x}\}$

   (b) Apply $(a(x).\overline{b}\langle x\rangle)\{^{e}/_{x}\}$

   (c) Apply $(a(x).\overline{b}\langle y\rangle)\{^{e}/_{x}, ^{d}/_{y}\}$

   (d) What's a minimal closing substitution for

      i. $\overline{a}\langle y\rangle \mid \overline{a}\langle b\rangle \mid y(x).\overline{x}\langle a\rangle$

      ii. $\overline{a}\langle y\rangle \mid y(x_1).x_1(x_2).x_2(x_3)...x_{n-1}(x_n).\mathbf{0}$

3. Are these processes structurally congruent?

   (a) $(\nu\, a)(\overline{c}\langle a\rangle \mid a(x).\overline{a}\langle a\rangle)$ and $(\nu\, b)(\overline{c}\langle b\rangle \mid a(x).\overline{a}\langle a\rangle)$

   (b) $(\nu\, a)(\overline{c}\langle a\rangle \mid a(x).\overline{a}\langle a\rangle)$ and $(\nu\, b)(\overline{c}\langle b\rangle \mid b(x).\overline{b}\langle b\rangle)$

   (c) $(\nu\, a)a(x).\overline{a}\langle b\rangle$ and $a(x).(\nu\, a)\overline{a}\langle b\rangle$

   (d) $(\nu\, a)c(x).\overline{a}\langle b\rangle$ and $c(x).(\nu\, a)\overline{a}\langle b\rangle$

4. Reduce these processes

   (a) $!(\nu\, a, c)(a.\overline{b} \mid !(c.\overline{a} \mid \overline{c}))$

   (b) $\overline{a}\langle c\rangle \mid \overline{a}\langle e\rangle \mid !a(z).\overline{b}\langle z\rangle$

5. Name Generator

   (a) Is $\mathbf{NN}(a) \stackrel{\text{df}}{=} !a(x).(\nu\, b)\overline{x}\langle b\rangle$ structural congurent with $\mathbf{NN}_1(a) = !a(x).(!(\nu\, b)\overline{x}\langle b\rangle)$?