

Coursework: Solutions

1. The free names and free variables are:

$$(a) \quad fn(P) = \{b\} \quad fv(P) = \{x\}$$

$$(b) \quad fn(Q) = \{a, c\} \quad fv(Q) = \{x, y\}$$

$$(c) \quad fn(R) = \emptyset \quad fv(R) = \{x\}$$

2. Substitutions:

$$(a) \quad (\nu b)!\bar{b}\langle a \rangle \mid !(\nu c)\bar{b}\langle c \rangle$$

$$(b) \quad a(x).\bar{b}\langle x \rangle$$

3. The reductions are:

$$\begin{aligned} & (\nu b)(a(x).\bar{x}\langle b \rangle) \mid !(\bar{a}\langle b \rangle \mid b(x).\mathbf{0}) \equiv (\nu b')(a(x).\bar{x}\langle b' \rangle \mid \bar{a}\langle b \rangle \mid b(x).\mathbf{0}) \mid !(\bar{a}\langle b \rangle \mid b(x).\mathbf{0}) \\ & \longrightarrow (\nu b')(\bar{b}\langle b' \rangle \mid b(x).\mathbf{0}) \mid !(\bar{a}\langle b \rangle \mid b(x).\mathbf{0}) \\ & \longrightarrow (\nu b')\mathbf{0} \mid !(\bar{a}\langle b \rangle \mid b(x).\mathbf{0}) \equiv !(\bar{a}\langle b \rangle \mid b(x).\mathbf{0}) \end{aligned}$$