Exercise 5

1. Find all the weak barbs of the processes below:

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

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

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

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

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

2. Find a separation context which proves:

   (a) $\overline{a} \mid \overline{b} \not\cong \overline{a}$

   (b) $\overline{a} \mid ... \mid \overline{a} \not\cong \overline{a}$

   (c) $a.\overline{c} \not\cong b.\overline{c}$

   (d) $\overline{c} \mid \overline{a}\langle b\rangle \not\cong \overline{c} \mid \overline{a}\langle d\rangle$

   (e) $a.\overline{b} \not\cong b.\overline{a}$

3. Show the inequality $P \not\cong Q$ where

   (a) $P \stackrel{\text{df}}{=} (\nu\, a)(\overline{a}\langle b\rangle \mid a(x).\overline{x}\langle c\rangle) \mid x(z).\overline{z}\langle y\rangle \mid y(z).\overline{z}\langle x\rangle$
   $Q \stackrel{\text{df}}{=} \overline{x}\langle y\rangle \mid y(z).\overline{z}\langle x\rangle \mid x(z).\overline{z}\langle y\rangle$

   (b) $P \stackrel{\text{df}}{=} (\nu\, b)(\overline{b}\langle y\rangle \mid b(x).\overline{a}\langle x\rangle) \mid \overline{a}\langle y\rangle \mid b(x).\overline{x}\langle c\rangle \mid \overline{z}\langle c\rangle$
   $Q \stackrel{\text{df}}{=} \overline{a}\langle y\rangle \mid b(x).\overline{x}\langle c\rangle \mid \overline{z}\langle c\rangle$

   (Note: for the open processes, you have to find a closing substitution σ such that $P\sigma \not\cong Q\sigma$.)

4. Show that the following equivalences hold, using the laws seen during the lectures:

   (a) $!((\nu\, a)a(x).P \mid Q) \mid (\nu\, a)\overline{a}\langle c\rangle \;\cong\; !Q$

   (b) $\overline{c} \mid !(a.\overline{b} \mid c.\overline{a} \mid b.\overline{c}) \mid c.\overline{a} \mid (\nu\, d)d(x).\overline{x}\langle a\rangle \;\cong\; !(a.\overline{b} \mid b.\overline{c} \mid c.\overline{a}) \mid \overline{a}$

   (c) $(\nu\, a, b)(\overline{a}\langle c\rangle \mid !(\overline{c}\langle b\rangle \mid P)) \;\cong\; (\nu\, d)!\overline{c}\langle d\rangle \mid !(P \mid P), a, b \notin fn(P)$

   (d) $!(a(x, y).\overline{a}\langle x, y\rangle \mid P) \mid !P \;\cong\; !P$

   (e) $(\nu\, a, b, c, e)(\mathbf{FW}\langle a, b\rangle \mid \mathbf{FW}\langle b, c\rangle \mid \mathbf{FW}\langle c, d\rangle \mid \overline{a}\langle e\rangle) \;\cong\; (\nu\, b)\overline{d}\langle b\rangle$

   (f) $\overline{c}\langle a\rangle \mid \mathbf{EQ}\langle a, b\rangle \mid \mathbf{EQ}\langle b, c\rangle \;\cong\; \overline{a}\langle c\rangle \mid \mathbf{EQ}\langle b, a\rangle \mid \mathbf{EQ}\langle c, b\rangle$