1. State carefully, without proof, the following results for PCF:
   (a) Compositionality
   (b) Soundness
   (c) Adequacy

2. Define the notion of contextual preorder, $\leq_{ctx}$, and contextual equivalence, $\approx_{ctx}$, in PCF.

3. Show that for all types $\tau$ and closed terms $M$ and $M'$ of type $\tau$, if $\llbracket M \rrbracket$ and $\llbracket M' \rrbracket$ are equal elements of the domain $\llbracket \tau \rrbracket$ then $M$ and $M'$ are contextually equivalent, that is,
   $$\llbracket M \rrbracket = \llbracket M' \rrbracket \in \llbracket \tau \rrbracket \Rightarrow M \approx_{ctx} M' : \tau$$

4. (a) Define what it means for a denotational semantics to be fully abstract.
   (b) Is PCF fully abstract? Give either a proof that it is or a counterexample to show that it is not.
   (c) Describe how PCF can be extended to obtain full abstraction.

You may state results proved earlier when answering the following questions:

5. Question 5, Paper 9, 2010. Parts (b) and (c).