9 Optimising Compilers (AM)

(*a*) Explain how a classical dataflow analysis, such as live variable analysis, can be alternatively seen as first walking over the flowgraph and emitting a set of equality constraints, and later solving these constraints to find their least solution. Your answer should make clear the syntactic form of the constraints, the space of values on which equality is to be performed, and what it means to be 'least'. You do not need to explain how the resulting constraints are solved. [4 marks]

(*b*) Reformulate your answer to part (*a*) so that the the flowgraph walker now produces only inequality constraints—but these replacement constraints should have the same least solution as your equality constraints given in part (*a*). [2 marks]

(*c*) Your answer to part (*b*) may have involved a *big union* or *big intersection* syntactic form, e.g. $\bigcup_{s \in S}(\ldots s \ldots)$. Either explain why it did not need to do so, or show how the flowgraph walker may alternatively emit inequality constraints which do not require use of *big union* or *big intersection* but whose solution is identical to that in parts (*b*) and (*a*). Again make clear the syntactic form of your constraints. Illustrate your answer by giving the (inequality-only) constraints emitted for liveness analysis of the flowgraph for the naively translated C code:

```
entry: x = rand();
       y = rand();
       z = 2 + y;
       if (x>10)
           return z;
       /* unspecified code having liveness L6 */
```

[5 marks]

(*d*) Summarise the purpose of *either* 0-CFA *or* Andersen's analysis. Also explain, for your chosen analysis, to what extent it fits the idea of "walk a data structure emitting constraints" and what form of information the analysis computes. You do *not* need to explain in detail the form of generated constraints. [4 marks]

(*e*) Both the analyses named in part (*d*) need to generate constraints more general than those in part (*b*), in particular constraints of the form $t \in S \Longrightarrow T \supseteq U$. Explain how this arises for your chosen analysis. [5 marks]