CS615 2010 Mid-semester Exam

Time: 120 mins — Total marks: 30

- ***The exam is open book and notes.***
- ***Results/proofs covered in class/problem sessions/assignments may simply be cited, unless specifically asked for.***
- ***Unnecessarily lengthy solutions will be penalized.***
- ***If you need to make any assumptions, state them clearly.***
- ***Do not copy solutions from others or indulge in unfair means.***

1. *[10 + 10 marks]* Consider the following program P in the language studied in class.

```
L1:     t := x;
L2:     while (t != y)
L3:        t1 := *t;
L4:        if (t1 = 0) then
L5:          *t := y;
L6:        else
L7:          *t := t1;
L8:        t := *t;
L9:     // end of while loop
```

   Let $\mathsf{list1}(u, v)$ and $\mathsf{list2}(u, v)$ be recursive predicates defined using separation logic as follows:

$$\mathsf{list1}(u, v) = (u \mapsto v) \vee \exists w. ((u \mapsto w) \star \mathsf{list1}(w, v))$$

$$\mathsf{list2}(u, v) = ((u \mapsto 0) \star (v \mapsto 0)) \vee \exists p, q. ((u \mapsto p) \star (v \mapsto q) \star \mathsf{list2}(p, q))$$

   Prove the following Hoare triples.

   (a) $\{\mathsf{list1}(x, p) \star \mathsf{list1}(y, p) \star \mathsf{list1}(p, 0)\}\ P\ \{\mathsf{list1}(x, p) \star \mathsf{list1}(p, p)\}$

   (b) $\{\mathsf{list2}(x, y)\}\ P\ \{\mathsf{list1}(x, 0)\}$.

   In the above proofs, you can make use of the fact that $\mathsf{list1}(u, v) \star \mathsf{list1}(v, w) \vdash \mathsf{list1}(u, w)$ for all u, v, w.

2. *[10 marks]* The following program Q is written in the language studied in class.

```
L1:  let f(x) =
L2:       if (x >= 0) then
L3:          ret := -x;
L4:       else
L5:          ret := 1 - f(x+1);
L6:  in
L7:    i := 0;
L8:    while (v != 0)
L9:       v := f(v);
L10:      i := i + 1;
L11:   // end of program
```

   Indicate whether $\{\mathsf{True}\}\ Q\ \{0 \leq i \leq 5\}$ is a valid Hoare triple. If yes, you must give a proof. Otherwise, you must provide a counterexample, i.e. a state that satisfies the pre-condition, but violates the post-