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## CS615 Quiz 2 (Spring 2019)

Max marks: 30

Time: 90 mins

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- *Be brief, complete and stick to what has been asked.*
- *Unless asked for explicitly, you may cite results/proofs covered in class without reproducing them.*
- *If you need to make any assumptions, state them clearly.*
- *Do not copy solutions from others. Penalty for offenders: FR grade.*

1. [15 marks] Consider the following program that updates integer variables on the stack and also memory on the heap.

```
struct llist {
    int d;
    struct llist *n;
};

simple_fun(llist *hd)
{
L1:   int c = 5;
L2:   llist *t = hd;
L3:   while ((hd != nil) && (hd->d != 0) && (c != 0)) {
L4:       hd = hd->n;
L5:       c = c - 1;
L6:   }
L7:   assert((c != 0) => listNonZero(t, hd));
L8:
}
```

The separation logic predicate  $listNonZero(p, q)$  is defined as follows:

$$listNonZero(p, q) \equiv (p = nil) \vee (p = q) \vee ((\exists v, r (p \mapsto [d : v, n : r]) \wedge (v \neq 0)) \star listNonZero(r, q))$$

Prove using separation logic that the program `simple_fun` never violates the assertion when started with the pre-condition `True`.

2. [15 marks] Consider the program given below, where all variables are of `int` type.

```
foo(int y, int z)
int x;
L1:   x := z;
L2:   while ((x != y) and (x != 0)) do
L3:       x := x - 1;
L4:   return(x);
```

We wish to determine which of the conditions  $x = y$  or  $x = 0$  holds when the function returns.

Using at most 5 predicates, design a Boolean program that allows you to answer the above question as precisely as possible. You are free to choose any 5 predicates on  $x$ ,  $y$  and  $z$ . However, you must justify your choice of predicates, and give the corresponding Boolean program.