Homework Assignment #2

Note

This assignment is due 2:20PM Thursday, May 12, 2011. Please write or type your answers
on A4 (or similar size) paper. Late submission will be penalized by 20% for each working day
overdue. You may discuss the problems with others, but copying answers is strictly forbidden.

Problems

1. (60 points) The following is a NuSMV model for two asynchronous processes that use a
   semaphore to achieve mutual exclusion.

```
MODULE main
VAR
  semaphore : boolean;
  proc1     : process user(semaphore);
  proc2     : process user(semaphore);
ASSIGN
  init(semaphore) := 0;


MODULE user(semaphore)
VAR
  state : {idle, entering, critical, exiting};
ASSIGN
  init(state) := idle;
  next(state) :=
    case
      state = idle                 : {idle, entering};
      state = entering & !semaphore : critical;
      state = critical             : {critical, exiting};
      state = exiting              : idle;
      1                            : state;
    esac;
  next(semaphore) :=
    case
      state = entering : 1;
      state = exiting  : 0;
      1                : semaphore;
```

```
    esac;
```

(a) Write all the necessary boolean formulae that specify the main module as a Kripke structure; you may define shorter substitute names for the variables to save space.

(b) Please draw BDD diagrams (as small as possible) for the formulae in 1a.

2. (40 points) Consider symbolic model checking of CTL on finite Kripke structures. Prove that, for any CTL formula f, the following statements hold:

(a) The set of states satisfying $\mathbf{AF}f$ is the least fixpoint of the function $\tau(Z) = f \vee \mathbf{AX}Z$.

(b) The set of states satisfying $\mathbf{AG}f$ is the greatest fixpoint of the function $\tau(Z) = f \wedge \mathbf{AX}Z$.