CS 151
Quiz 2

Instructions:

1. Please verify that your paper contains 6 pages including this cover.
2. Write down your Student-Id on the top of each page of this quiz.
3. This exam is closed book. No notes or other materials are permitted.
4. Total credits of this quiz are 35 points.
5. To receive credit you must show your work clearly.
6. No re-grades will be entertained if you use a pencil.
7. Calculators are NOT allowed.
Q1: [Latch analysis] [10 points]

Shown below is a NAND implementation of gated D-latch:

![Diagram of NAND implementation of gated D-latch]

The timing diagrams of D and C are shown below. Show the timing diagram for Q and T:

(Assume that Q=1 and T=0 at t0 and there is no gate delay)
Q2: [Mux/Decoder application] [15 points]

(a) For function $F(a,b,c) = ab'c + a'bc' + a'b'c' + a'b'c + abc$:
Implement $F$ by means of a 4-to-1 multiplexer. You should not simplify the function. (8 points)

(HINT: You can use NOT gates to invert the input to the MUX)
(b) For the same function \( F(a,b,c) = ab'c + a'bc' + a'b'c' + a'b'c + abc \): 
Implement \( F \) by means of a 3-to-8 decoder. You should not simplify the function. 
(7 points)
Q3: [FSM design] [10 points]

You want to design a food and water dispenser for your dog. You have decided to implement a circuit that has two buttons, a RED button, and a BLUE button, and the ON switch. As long as the ON switch is on, the circuit is enabled. If your dog hits the RED button three consecutive times, that means he is hungry, so the signal that triggers the food dispenser is activated (denoted by a signal $F$), and the State Machine should go back to the start state. If your dog hits the BLUE button two consecutive times, that means he is thirsty, and the signal that triggers the water dispenser is activated (denoted by a signal $W$), and the State Machine should return to the start state. If your dog hits the wrong button at any time, the circuit resets to the start state. For example, if your dog hits an invalid sequence ($RED, RED, BLUE$), the State Machine should be reset to the start state. Assume your dog can push only one button at a time. If the ON switch is off, the State Machine should be reset to the start state.

a) Draw a black box of the State Machine with the inputs and outputs. (4 points)
b) Design a State Machine to control this circuit (draw a state diagram). (6 points)