Computer Science 240
Sequential Circuits
Assignment for Lab 5

Flip-flops are **sequential circuits**, circuits whose output depends not only on the present value of its input signals but also on the value of past inputs. This is in contrast to combinational logic, whose output is a function of only the present input (the other circuits you have studied up to this point, such as basic gates, multiplexers, decoders, and ALU).

Because latches and flip-flops can store a state of 0 or 1, they are used as 1-bit memories, and can be used to create larger, n-bit memories such as registers and RAM. We will use those circuits in our implementation of an instruction set architecture.

Flip-flops are also used for solving problems which can be described by a Finite State Machine. Go to the following link:

http://www.cs.princeton.edu/courses/archive/spr06/cos116/FSM_Tutorial.pdf

which steps you through the process of solving a simple problem of this kind.

Read carefully to understand the steps used to design a circuit for the elevator.

A traffic light controller is another example of such a problem. Assume there is an intersection with a single light controlling the flow of traffic:

The light cycles from green to yellow to red, then back to green.

For simplicity, assume that the cycles are equally spaced, and that a transition occurs every x seconds (this will be controlled by a clock signal to the flip-flops, and will not be considered an input to the circuit for the purposes of the state machine).

1. How many states are needed?

Label the states Go, Yield, and Stop, and draw the state transition diagram:

2. Fill in a state table:

Current State	Next State
Go	
Yield	
Stop	

3. Assume you will use D flip-flops for the circuit. What is the minimum number of flip-flops you need to accomplish this? (NOTE: each flip-flop has a possible state of either 0 or 1, so can represent 2 different states of a finite state machine).

One of the available flip-flop states will be unused. It is possible to get into the unused state, because when the circuit is first powered up, the flip-flops may initialize to that state. Therefore, you must define the behavior of the circuit for this possibility, as well (what light should be on in the unused state, and what should be the next state?).

4. Assuming that the red light will be lit in the unused state, and that the next state will be a green light, modify your state table to include this:

Current State	Next State
Go	
Yield	
Stop	
Unused	

5. Assign state numbers to flip-flop outputs and construct the transition table (for consistency, let's assume the following encoding). Also indicate which light will be on for each state:

State	Current State (encoded)	Next State	Outputs (1 if light is lit, 0 otherwise)		
	Q1 Q0	D1 D0	Green	Yellow	Red
Go	0 0				
Yield	0 1				
Stop	1 0				
Unused	1 1				

6. Fill in Karnaugh-maps and determine the minimized expressions for each D flip-flop (D0 and D1):

D1	Q0 0	1
Q1 0		
1		

D0	Q0 0	1
Q1 0		
1		

D1 =

D0 =

7. Do the same for each output (Green, Yellow, and Red):

Green	Q0 0	1
Q1 0		
1		

Green =

Yellow =

Yellow	Q0 0	1
Q1 0		
1		

Red =

Red	Q0 0	1
Q1 0		
1		