Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

6.111 - Introductory Digital Systems Laboratory

Quiz 1 Friday, March 2, 2001

1	.....(15)
2	.....(20)
3	.....(25)
4	.....(40)
TOTAL	.....(100)

NAME .....

Indicate Your Section

( ) Danny Seth 12 PM
( ) Peter Agboh 1 PM
( ) Todd Hiers 2 PM
( ) Brian Perrin 3 PM

This quiz is **Closed Book:** One handwritten "crib" sheet is allowed.

Put your name on all sheets and indicate your section on this page.

Write all your answers directly on the quiz.

Show all of your work.

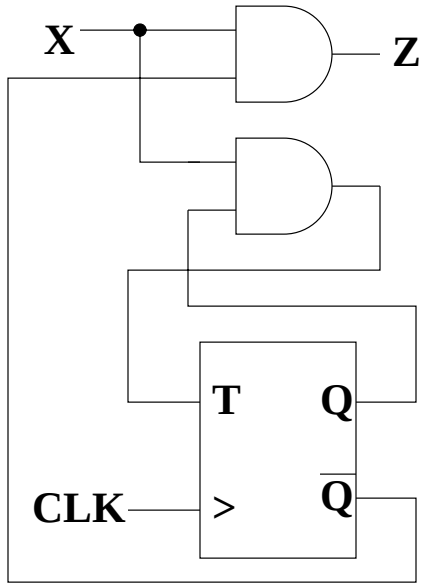
You are not required to use a logic template, but you must **make sure your answers are legible**.

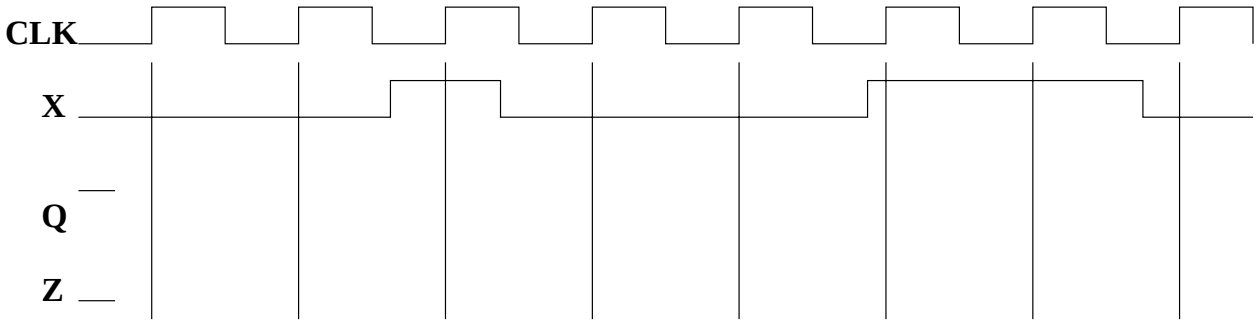
Problem 1 (15 points)

What would you see?

Assume that X satisfies the setup and hold times of the type T flip-flop and that the AND gates are "fast enough".
Also assume that the flip-flop, Q, is initially in the '1' state, that is that Q is high.
Also assume that the CLK to Q delay is a small positive number that is much less than the period of CLK.

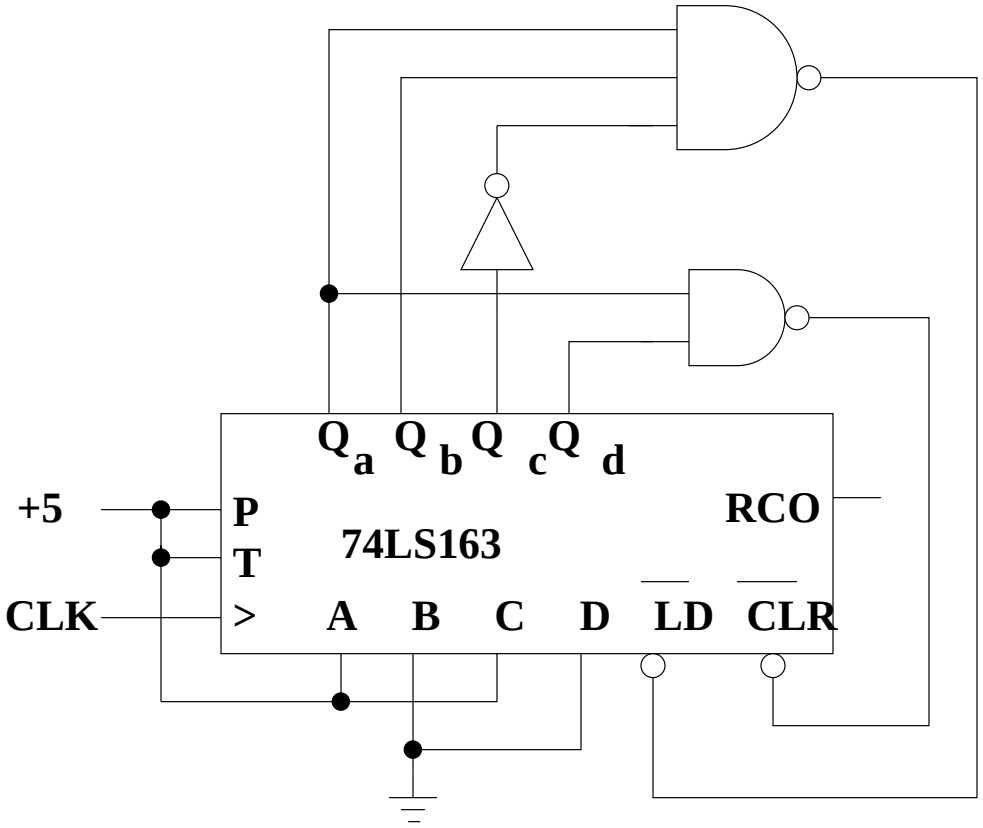
Draw the waveforms that you would expect to see on an oscilloscope for the output Z and the flip-flop output Q.





Problem 2 (20 points)

Fun with a counter!
Consider the following counter.



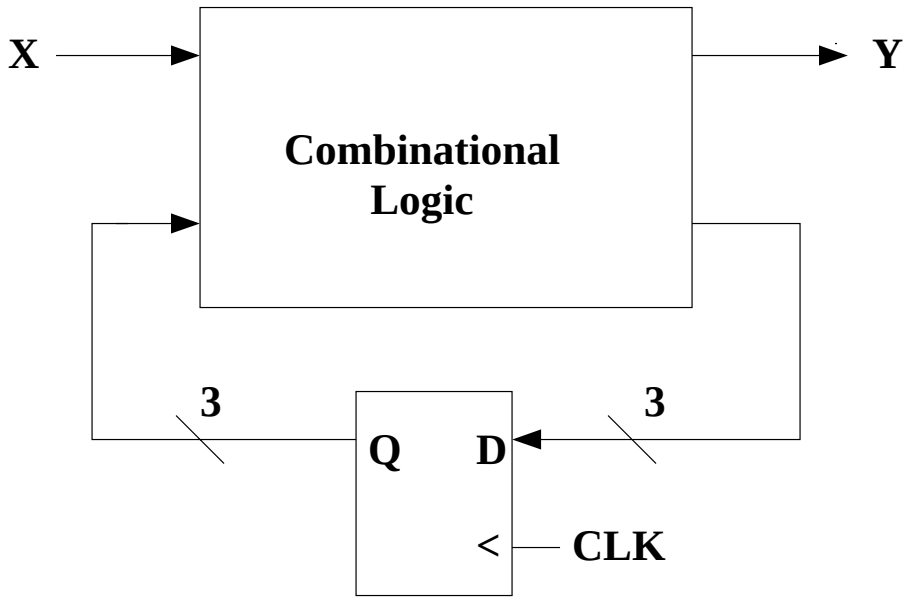
a) Starting from 0, give the counting sequence of this counter.

b) Give the counting sequence if Qc was not used as an input to the top NAND gate, i.e., if the top NAND gate had only two inputs, Qa and Qb.

Problem 3 (25 points)

Interpreting VHDL

Assume that X is synchronized to CLK and that the combinational logic is "fast enough". Draw and label the state diagram specified by the figure below and the VHDL code on the next page.

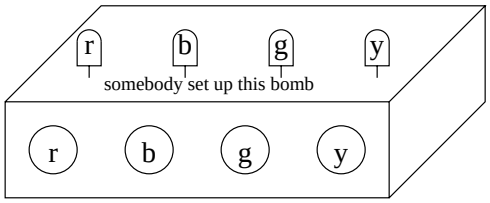


```
library ieee;
use ieee.std_logic_1164.all;

entity combinational is
  port (x : in std_logic;
        oldstate : in std_logic_vector(2 downto 0);
        newstate : out std_logic_vector(2 downto 0);
        y : out std_logic);
end;

architecture comp of combinational is
begin

  with oldstate select
   y <=
    '0' when "000",
    '0' when "011",
    '1' when "001",
     x  when others;

process(oldstate, x)
begin
  case oldstate is
     when "000"  =>
       if (x = '1') then newstate <= "010";
       else newstate <= "001";
       end if;
     when "001"  =>
       if (x = '1') then newstate <= "011";
       else newstate <= "010";
       end if;
     when "010"  =>
       newstate <= "100";
     when "011"  =>
       if (x = '1') then newstate <= "100";
       else newstate <= "010";
       end if;
     when "100"  =>
       if (x = '1') then newstate <= "011";
       else newstate <= "010";
       end if;
     when others =>
       newstate <= "000";
   end case;
end process;

end comp;
```

Problem 4 (40 points)

Sabotage !!!

This morning, someone tried to get out of their 6.111 quiz by planting a bomb in this room. Fortunately, there were a number of students on hand, all of them 6.111 alums, who noticed the bomb and investigated. Upon inspection, they discovered, amongst the wiring, four push-buttons which could deactivate the bomb. However, the buttons must be pushed in the right order, or the bomb would go off. Each button was also wired to a colored LED, each a different color: red, blue, green, and yellow. All of the LEDs are on.



The bomber also dropped his bomb deactivation hints on the floor, in his haste to escape:

1) The bomb is deactivated when all of the LEDs are off.

2) Pushing a button turns off the LED it is connected to. Do not push more than one button at once.

3) Do not turn off the yellow LED if the green LED is still on, or the bomb will explode.

4) If both the red and blue LEDs are still on, do not turn off the green or yellow LEDs.

5) Do not turn off the yellow LED if the blue LED is still on, or the bomb will explode.

6) If the red LED is turned off while any other LED is still on, the bomb will explode! ALWAYS TURN OFF THE RED LED LAST!!!

The students quickly realized they could make a Karnaugh Map of conditions under which the bomb would explode, based on these rules.

a) Fill in the Karnaugh Map below using the descriptions listed above. R, B, G, and Y are the red, blue, green, and yellow LEDs, respectively. A value of 0 on the Karnaugh Map means the bomb does not explode, while a value of 1 means it does. The start and end states have been provided.

RB \ GY	0 0	0 1	1 1	1 0
0 0	0			
0 1				
1 1			0	
1 0				

Use this Karnaugh Map for parts b, c, and d.

RB \ GY	0 0	0 1	1 1	1 0
0 0	**0**	**1**	**1**	**1**
0 1	**0**	**1**	**0**	**0**
1 1	**1**	**1**	**0**	**1**
1 0	**1**	**1**	**1**	**1**

b) Based on the Karnaugh Map on this page (which is NOT the answer for part a above), what is the MSP for the explode function?

MSP =

c) If you were the bomber and, being a poor college student, could only afford NAND gates, how would you wire the explode circuitry? Use the Karnaugh Map on this page. The circuitry should take in four values (r, b, g, and y), and have one output (explode) which is high if the bomb explodes.

d) Based on the Karnaugh Map on this page, give the sequence of buttons that will deactivate the bomb.