ECE 204 - THE VERY BASICS - INVESTIGATION 2
INTRODUCTION TO SWITCHING CIRCUITS - PART II

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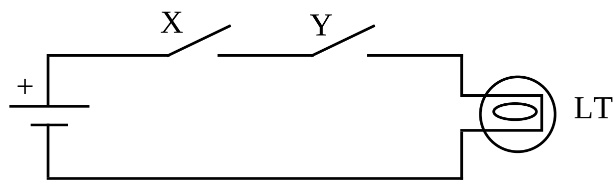
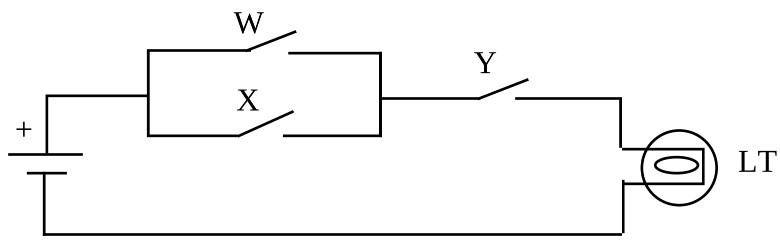
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

In Investigation 1 we showed how we could specify what's going on in switching circuits like the following

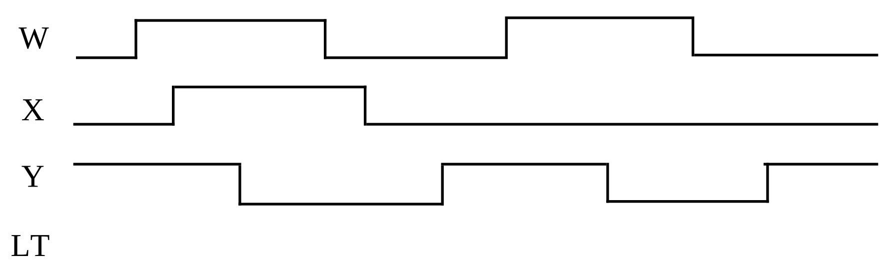


with timing diagrams, with sentences and with Truth Tables. The objective of this Investigation and the next is to show how we can write "algebra" equations for our switching circuits. These algebra equations, referred to as logic equations, are significantly different in many important ways from the "regular" algebra equations we worked with in ECE 109 to analyze resistor circuits - but they'll have a lot in common too.

1. We begin with a review problem. Given the following switching circuit



   a. Write out the truth table in terms of H's and L's
   b. Complete the following timing diagram

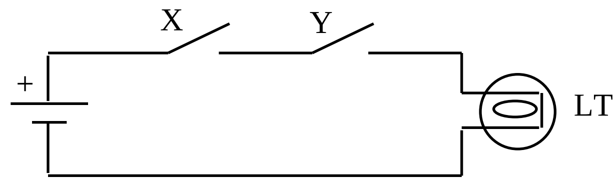


   where the larger voltage is H and the lower one L

2. Truth Tables like the one from Problem (1) are great for describing the operation of switching circuits. We use them all the time. But Truth Tables can get very large as the number of switches increases. How many rows are there in a Truth Table for a switching circuit with
   a. 5 switches
   b. 10 switches

c. n switches

3. From Problem (2) we know that Truth Tables can get very large very quickly. Luckily there are more compact ways to describe switching circuits with equations. But first we must understand how to describe switching circuits with **logic statements**. Logic statements are really just shorthand for the written descriptions we worked with in Investigation 1. For the following series switching circuit



the corresponding *logic statement* is

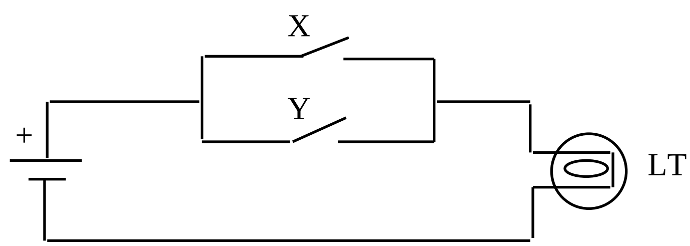
If X and Y then LT

Which is simply shorthand for the statement

If X = H and Y = H then LT = H. Otherwise LT = L

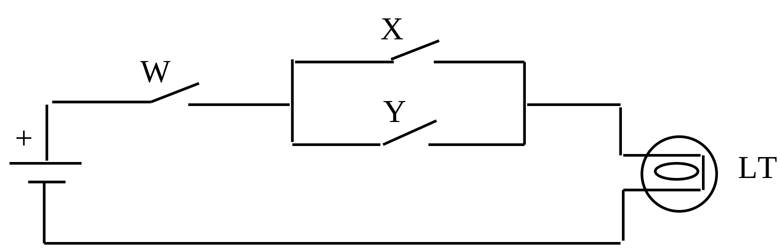
Which tells us that if both switches are CLOSED then the light LT will be ON. Otherwise it will be OFF. We call such if-then statements logic statements because that's the form used by mathematicians in formal logic.

Now make use of these results to write the logic statement for the following parallel switching circuit

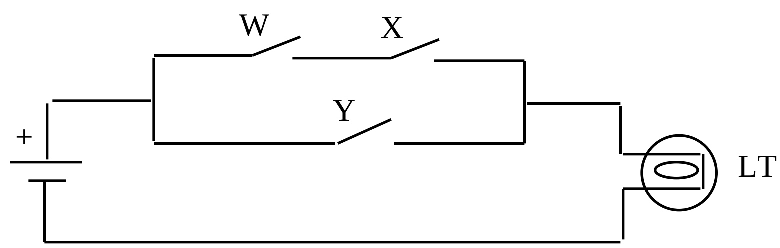


4. Write out the logic statements for each of the following circuits. Be sure to use parenthesis to avoid ambiguities about what is AND'ed and what is OR'ed with what.

a.



b.



5. When we look at a logic statement like the following

   If X and Y then LT

   we see that the value of LT is determined by the values of X and Y. And so the value of LT is a function of the values of X and Y as follows

   LT = F(X, Y)

   This leads us to the realization that we can write our logic statement

   If X and Y then LT

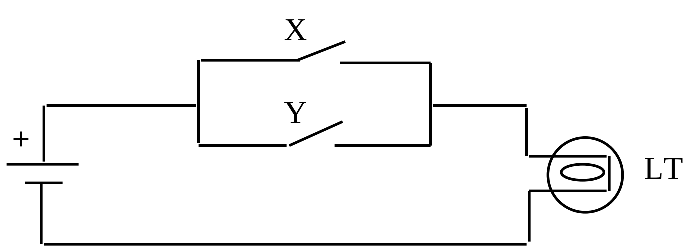
   as a **logic equation** as follows

   LT = X and Y

   with the understanding that it means the following:

   If X = H and Y = H then LT = H. Otherwise LT = L.

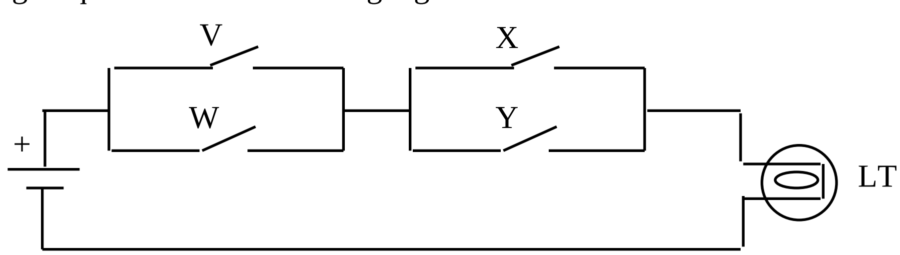
   Now given the following switching circuit



   a. Write the logic equation for LT
   b. Write out the meaning of your logic equation in part (a)
   c. Why do we refer to switching circuits as *digital logic circuits* or simply *logic circuits*

6. Write the logic equations for the digital logic circuits in Problem (4). Be sure to use parenthesis to avoid any ambiguities.

7. Write the logic equation for the following logic circuit

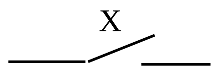


8. Make up your own logic circuit and then

a. Write out a Truth Table for your circuit
b. Write the logic equation for your circuit

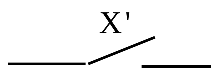
9. Write the Truth Table for the logic equation LT = (W and X) or Y

10. Up to now all the switches in our logic circuits have been CLOSED when their inputs are HIGH and OPEN when their inputs are LOW as indicated in the following truth table



X	**SWITCH**
L	OPEN
H	CLOSE

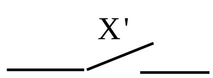
But as it turns out we often want our switches to CLOSE when X=L and OPEN when X=H. When we want this to happen we write the X's with primes as follows



The prime means that the signal X has been changed (**inverted**) before it is applied to the switch as follows

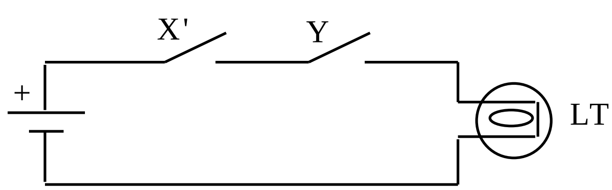
X	**X'**
L	H
H	L

The switch will then respond to the value of X as follows



X	**SWITCH**
L	CLOSE
H	OPEN

We call X' the **complement of X** and refer to it as **X prime** or **NOT X**. If a logic circuit has an X' in it like the following

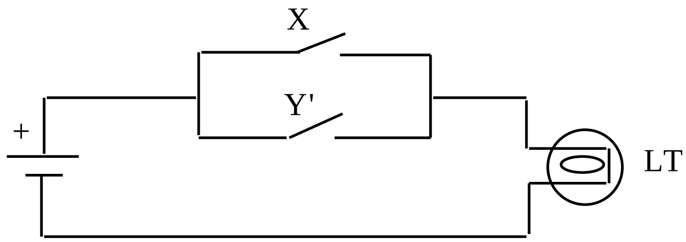


then its logic equation and truth table are as follows

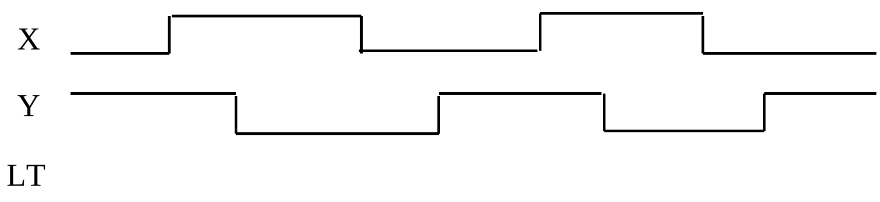
LT = X' and Y

X	**Y**	**LT**
L	L	L
L	H	H
H	L	L
H	H	L

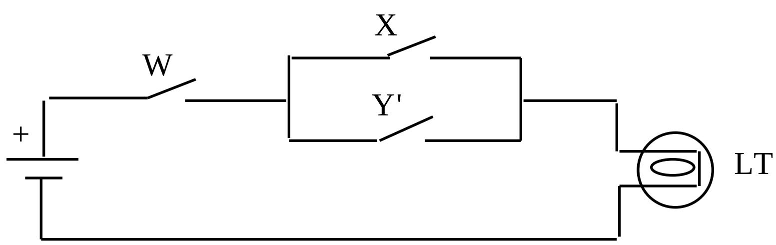
And so for this circuit LT will light when X=L and Y=H. We say that LT equals not X and Y. **Memorize** the results of this problem. Then for the following logic circuit



a. Write the logic equation for LT
b. Write the Truth Table for LT
c. Complete the following timing diagram for LT



11. Find the logic equation for LT in the following logic circuit



12. Draw a logic circuit for the logic equation LT = (W' and X) or Y