CSC B58 – Winter 2015

Assignment 1 – Boolean Logic, Circuits, and Boolean Algebra

The due date for this assignment is: Mon. Jan. 26, at 11am (beginning of lecture)

Name (last, first):

Student No.:

I certify that I have read the UTSC policy on academic honesty and plagiarism, and that all work I am providing with this assignment is my own.

Student signature: ______________________________

Note: There is a penalty of 3 marks for failing to complete the above section.

Part	Marks
1	/ 13
2	/ 13
3	/ 14
4	/ 10
Bonus	/ 3
Total	/ 50

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Assignment 1 – Boolean Logic, Circuits, and Boolean Algebra

This assignment is intended to help you practice and strengthen your understanding of the material covered during the past few lectures. As you work on it, please pay attention to any questions you may find difficult to understand or solve, as this typically indicates you may need to study particular topics a bit further. When that happens, please come to office hours and ask! We are happy to help you achieve a better understanding of the material.

Learning Objectives – after completing this assignment you should be able to:

Analyze simple circuits built with transistors

Use the laws of Boolean Algebra to simplify logic expressions and ***if statements***

Manipulate truth tables, and use them to derive Boolean Algebra expressions for logic functions

Prove Boolean expression equivalences via truth tables, or algebraic manipulation

Form DNF expressions from truth tables, and implement these functions using logic components

Skills Developed:

Working with truth tables, logic functions, and circuits that contain logic gates

Using Boolean Algebra laws to manipulate logic expressions

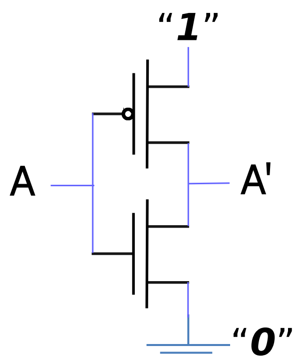
Verifying the validity of logic equivalences, and the correctness of your own work!

References:

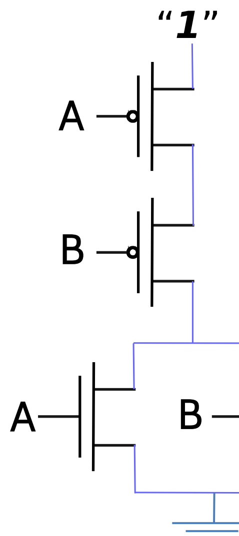
Your lecture notes on Boolean Algebra, logic functions, logic components, and circuits.

Your course instructor and/or TA! (did I mention we are happy to help?)

1) Analyze the transistor-based circuit shown below, and answer the questions. ***Note: A and B are inputs, Q is the output.***



*An inverter (**NOT**) gate*



*A **NOR** gate*

1a) (3 marks) Draw the diagram showing the state of the transistors for the ***NOR*** gate when A=1, B=0

1b) (10 marks) Using as building blocks the ***NOT*** and ***NOR*** gates shown above, ***create a new circuit*** that implements the ***Logic AND*** function. ***Show*** the ***Boolean Algebra expression*** corresponding to your circuit and prove that it reduces to the ***AND*** function.

(use a clean sheet of paper for this)

Please attach all written work for this question ***immediately*** after this page.

2) Boolean Algebra.

Note: In the expressions below, ***x'*** stands for ***not x.***
For each operation ***list the name of the law you used***.

2a) (3 marks) Simplify: $(F+G)'(F'G') + ((G'(G+F'))' + (F'G'))$

2b) (5 marks) Draw the circuit using ***logic gates*** for ***both*** the expression in ***2a)*** and your simplified result.

2c) (5 marks) Simplify: $((A'B)'(BC'A')' + (B+C'+A')')(B'(C'+A))' + (BC')'$

Please attach all written work for this question ***immediately*** after this page.

3) That Funky Logic...

You are in charge of performing a ***code review*** on an upgrade one of your colleagues is proposing for a major component within the payroll module of your company's IT system.

Part of the upgrade consists of simplifying very convoluted logic regarding bonus payments. The original code contains the following conditional statement deciding whether an employee gets a bonus or not:

```
if ((age>=60 and extra_hours>12) or (age<60 and extra_hours>20))
    and (((not(late_arrivals) and (full_meeting_attendance)) or
   (rank>SUPERVISOR and age>=60)) or (not(age<60) and
   (full_meeting_attendance))  then  Bonus=TRUE;
```

Your colleague has replaced the above statement with the one below:

```
if ((age>=60) and (full_meeting_attendance or (extra_hours>12 and
    not(late_arrivals)))) or (age<=60 and extra_hours>20 and not
    (late_arrivals) and (full_meeting_attendance)) then Bonus=TRUE;
```

a) (5 marks) Determine the ***Boolean conditions*** that are needed to represent the statements above, assign a Boolean variable to each condition.
(e.g. in the statement if (day==MONDAY and time==1200) we have two variables A – True if the day is Monday
B - True if the time of day is 12:00)

Please attach all written work for this question ***immediately*** after this page.

3) That Funky Logic.. (continued).

b) (2 marks) Write a Boolean expression to represent the original conditional statement.

c) (2 marks) Write a Boolean expression to represent the updated conditional statement

d) (5 marks) Prove whether or not the two statements are logically equivalent. ***If they are not equivalent, write the correct simplified statement.***

Please attach all written work for this question ***immediately*** after this page.

4) Consider carefully the ***truth table*** shown below

A	***B***	***C***	***f(A,B,C)***
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

4a) (3 marks) Write the logic function ***in DNF form*** that implements the function f(A,B,C) defined by this truth table.

4b) (3 marks) Show the diagram implementing the ***DNF*** function in ***4a)*** directly (using only ***NAND*** gates). Remember that ***any Boolean function can be implemented with at most 3 levels of gates.***

4c) (5 marks) Show the implementation of the above function using ***a multiplexer***. The control lines for the multiplexer correspond to B and ***A in that order*** (***s1*** is connected to ***B***, ***s0*** is connected to ***A***). Be sure to show the residuals table!

Please attach all written work for this question ***immediately*** after this page.

Bonus: (3 marks)
Complete this section after you have solved the rest of your assignment
- there are no right answers! - this is for feedback only, and will remain confidential.

Self evaluation: This section is meant to help you find topics that are giving you trouble. Focus your studying on these topics.

I will look at this also, to see what topics are giving most people trouble, we will devote more time to these topics during tutorials, and if necessary, use tutorials for reviewing that material

1.- How well do you understand how a transistor switch works?
well / partially / not at all

2.- How confident are you that you can analyze a new, simple circuit with transistors?
confident / somewhat confident / not confident

3.- How comfortable are you handling truth tables and logic expressions?
very / somewhat / not comfortable

4.- At this point, how familiar are you with basic Boolean Algebra identities and their use?
very / somewhat / not familiar

5.- How well do you understand the conversion from truth table to DNF and the subsequent implementation with multiplexers?
well / partially / not at all

6.- How useful was this assignment in helping you achieve the learning goals stated on P1?
very useful / somewhat useful / not useful at all
(if not useful, please give a brief comment of why, and what would have helped you achieve these learning goals – use the back of the page as needed)

7.- What topic or concept would you like to see a review of (either in lecture or tutorial)?