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Introduction to Computer Science, Winter Semester 2016
Practice Assignment 10
Discussion: 31.12.2016 - 5.01.2017

Exercise 10-1

Use AND, OR and NOT gates to implement the circuits represented by the following two expressions:

$$\begin{aligned} S &= P'X'Y + P'XY' + PX'Y' + PXY \\ C &= P'XY + PX'Y + PXY' + PXY \end{aligned}$$

Exercise 10-2

Draw a logic circuit that corresponds to each of the expressions shown below:

a) $AB' + A'C'D' + A'B'D + A'B'CD'$

b) $B' + A'C'D'$

c) $(A' + B' + C + D')(A + B + C' + D)$

Exercise 10-3

Given the following the following truth table, where **A**, **B** and **C** are the input variables and **X** is the output variable.

A	**B**	**C**	**X**
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

a) Use the sum-of-products algorithm to find the Boolean expression that describes the output of the truth table.

b) What is the functionality of the circuit?

c) Draw the Boolean circuit. **Note** that each gate can have only two inputs.

Exercise 10-4

Simplify the Boolean expressions to a minimum number of literals using the Boolean algebra. Please mention the applied rules.

$x + 0 = x$	$x * 1 = x$	
$x + 1 = 1$	$x * 0 = 0$	
$x + x = x$	$x * x = x$	
$x + x' = 1$	$x * x' = 0$	
$(x')' = x$		
$x + y = y + x$	$xy = yx$	Commutativity
$x + (y + z) = (x + y) + z$	$x(yz) = (xy)z$	Associativity
$x(y + z) = xy + xz$	$x + yz = (x + y)(x + z)$	Distributivity
$(x + y)' = x'y'$	$(xy)' = x' + y'$	DeMorgan's Law

- $ABC + ABC' + A'B$
- $(A + B)'(A' + B')$
- $(A + B' + AB')(AB + A'C + BC)$
- $P'XY + PX'Y + PXY' + PXY$
- $(AB)'(A + B)$
- $B + A'C + AB'$
- $AB + A'C + BC$

Exercise 10-5

Given the following Boolean expression, simplify it to a minimum number of literals using the Boolean algebra. Please mention the applied rules.

$$((A + B)(B' + C' + D')) + B'C'(A + B' + C) + A'C + D$$

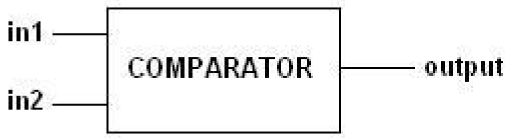
Hint: The circuit of the simplified expression consists of zero gates.

Exercise 10-6 Boolean Circuits
Comparator

A one-bit comparator is a circuit that takes two numbers consisting of one bit each and outputs 1 if the numbers are equal, 0 otherwise.

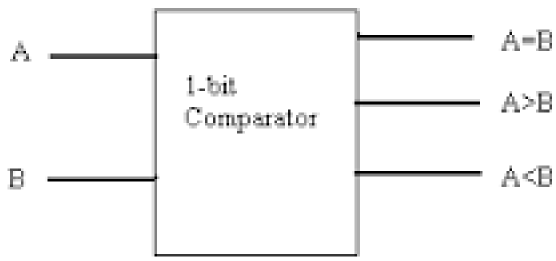
a) Construct a truth table for a one bit equality comparator.

b) Assume that you have already manufactured one-bit comparators.



Design a circuit that uses one-bit comparators and AND-gates to check the equality of two numbers consisting of 4 bits each.

c) Assume that our one-bit comparator was modified to have two input variables A, B and three output variables (one checking for $A = B$, one checking for $A > B$ and one checking for $A < B$).



Design a circuit that uses the modified one-bit comparators with other gates to compare two numbers consisting of 2 bits each. **Do not draw the truth table.**