Computer Architecture and Programming Languages
Jacobs University Bremen
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Course: CO20-320241
September 16th, 2019

Homework 2 - Logic Circuits and Boolean Expressions

- Template file for submitting the solutions:
  https://grader.eecs.jacobs-university.de/courses/320241/2019_2/lectures/template_hw.tex
- The TAs are grading solutions to the problems according to the following criteria:
  https://grader.eecs.jacobs-university.de/courses/320241/2019_2/Grading_Criteria_CAPL.pdf

Problem 2.1 *Number systems and counting* (1 point)

Write down the result after incrementing by one (i.e., adding 1) each of the following numbers:

(a) 777_8

(b) 888_{16}

(c) 32007_8

(d) 32108_{16}

(e) $8BFF_{16}$

(f) 1219_{16}

Problem 2.2 *Logic circuits* (2 points)

For each of the following expressions, construct the corresponding logic circuit, using AND and OR gates, and INVERTERS.

(a) $\mathtt{x} = \overline{\mathtt{A} \cdot \mathtt{B} \cdot (\mathtt{C} + \mathtt{D})}$

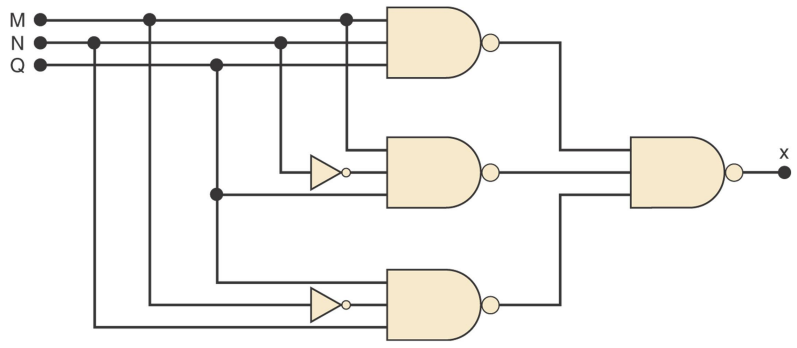
(b) $\mathtt{x} = \overline{\mathtt{A} + \mathtt{B} + \overline{\mathtt{C}} \cdot \mathtt{D} \cdot \overline{\mathtt{E}}} + \overline{\mathtt{B}} \cdot \mathtt{C} \cdot \overline{\mathtt{D}}$

(c) $\mathtt{x} = \overline{\mathtt{W} + \mathtt{P} \cdot \overline{\mathtt{Q}}}$

(d) $\mathtt{x} = (\mathtt{A} + \mathtt{B}) \cdot (\overline{\mathtt{A}} + \overline{\mathtt{B}})$

Problem 2.3 *Algebraic simplification* (2 points)

Write down the truth table of the logic circuit below, then the corresponding sum-of-products expression, and finally simplify the logic circuit using Boolean algebra. At every step of the simplification refer to specific rules/theorems you apply by using some kind of labels (e.g., $R1$, $R2$, $R3$ or similar). Do not forget to write down the mapping between your labels and rules.



Problem 2.4 *Boolean theorems* (1 point)

Prove the following identities by providing complete truth tables:

(a) $\mathtt{X} + \overline{\mathtt{X}} \cdot \mathtt{Y} = \mathtt{X} + \mathtt{Y}$

(b) $\overline{\mathtt{X}} + \mathtt{X} \cdot \mathtt{Y} = \overline{\mathtt{X}} + \mathtt{Y}$

Problem 2.5 *Complete each expression* (1 point)

Minimize the following simple expressions:

(a) $\mathtt{A} + 1 =$

(b) $\mathtt{A} \cdot \mathtt{A} =$

(c) $\mathtt{B} \cdot \overline{\mathtt{B}} =$

(d) $\mathtt{C} + \mathtt{C} =$

(e) $\mathtt{x} \cdot 0 =$

(f) $\mathtt{D} \cdot 1 =$

(g) $\mathtt{D} + 0 =$

(h) $\mathtt{C} + \overline{\mathtt{C}} =$

(i) $\mathtt{G} + \mathtt{G} \cdot \mathtt{F} =$

(j) $\mathtt{y} + \overline{\mathtt{w}} \cdot \mathtt{y} =$

Problem 2.6 *DeMorgan's theorems* (1 point)

Prove DeMorgan's theorems using truth tables.

Problem 2.7 *Determine and simplify logic expression* (2 points)

Consider the following truth table. Determine the sum-of-products expression and then simplify the resulting expression using rules/theorems of the Boolean algebra. At every step of the simplification refer to specific rules you apply by using some kind of labels (e.g., $R1$, $R2$, $R3$ or similar). Do not forget to write down the mapping between your labels and rules.

A	B	C	D	X
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

Problem 2.8 *Karnaugh-map* (2 points)

Consider the truth table from **Problem 2.7**. Simplify the resulting sum-of-products expression using a Karnaugh-map. Shortly describe your steps, such that one can follow.

How to submit your solutions

You can submit your solutions via *Grader* at **`https://grader.eecs.jacobs-university.de`** as a generated PDF file from the given template TEX file.
If there are problems with *Grader* (but only then), you can submit the file by sending mail to `k.lipskoch@jacobs-university.de` **with a subject line that starts with CO20-320241**.

Please note, that after the deadline it will not be possible to submit solutions. It is useless to send solutions by mail, because they will not be graded.

This homework is due by Monday, September 23rd, 23:00.